QUEENSLAND

GOVERNMENTAL INVESTIGATIONS

MAREEBA-DIMBULAH IRRIGATION DEVELOPMENT

1952

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

REPORT

ON

PROPOSALS FOR WATER CONSERVATION AND IRRIGATION DEVELOPMENT IN THE MAREEBA-DIMBULAH AREA

by

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Commissioner of Irrigation
and Water Supply

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1952

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IRRIGATION AND WATER SUPPLY COMMISSION.

MAREEBA-DIMBULAH IRRIGATION PROJECT

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Establishment of Mareeba-Dimbulah Irrigation Undertaking and Mareeba-Dimbulah Irrigation Area.

19th March, 1952.

MEMORANDUM FOR:

THE HONOURABLE THE MINISTER FOR LANDS AND IRRIGATION.

Further to my report and recommendations submitted on the establishment of the Mareeba-Dimbulah Irrigation Project, I submit the following statement of details of the project in accordance with the requirements of section 7 of the Irrigation Acts, for submission to the Legislative Assembly in connection with the establishment of the Mareeba-Dimbulah Irrigation Undertaking and the constitution of the Mareeba-Dimbulah Irrigation Area.

The details submitted herewith are based on the proposal to construct a dam at 63M. on the Barron River with a capacity of 320,000 acre feet, which corresponds to Stage 1 of Alternative Scheme B set out in the report, and in addition the construction of a weir at 167M. on the Walsh River with a capacity of 840 acre feet.

(a) Boundaries and Extent of Area.

The map—Fig. 1—attached hereto shows the boundaries and extent of the lands proposed to be comprised in the Irrigation Area.

(b) Description of Scheme and Purpose of Works.

The scheme comprises—

(i.) The construction of a weir on the Walsh River at 167M. and the construction of a channel from this weir to convey water to existing tobacco farms on the South bank of the Walsh River between Parada and Dimbulah.

(ii.) The construction of a dam on the Barron River near Tinaroo Falls with a capacity of not less than 320,000 acre feet of water.

(iii.) The construction of main and distributory channel systems to convey water from the dam to lands in the area shown green in the map—Fig. 5—in the report. The main channel system from the Tinaroo Falls dam will connect to that constructed from the weir on the Walsh River in (i.) above and combined with the supply available from the Walsh River will permit full development of the lands on the South side of the Walsh River within the area;

(iv.) The supply of water from the Tinaroo Falls reservoir and the Walsh River to existing and new farms developed in the area for irrigated production primarily of tobacco and also mixed agriculture and possibly fodder production;

(v.) The construction of drainage works to serve farms in the area, for the removal of storm water runoff, and surplus irrigation water. The effect of these works will be to safeguard the irrigated lands from soil deterioration due to excessive soil moisture and thus protect the assets created in the water conservation, irrigation and farm development works.

(vi.) Provision for the satisfactory rural and urban development of the area by construction of roads to reasonable pioneer standards and the laying out and opening of lands in urban centres suitably situated throughout the area.

(vii.) Provision of office and staff accommodation as required throughout the area to provide for the satisfactory administration and management of the project.

(c) Nature and Extent of Proposed Works.

The plan—Fig. 3—attached to the report shows the approximate location, nature and extent of the proposed works which comprise—

(i.) Storage Works—

(*a*) A weir at A.M.T.M. 167M. on the Walsh River which will be a mass concrete gravity weir 30 feet high and will store some 840 acre feet of water.

(*b*) A mass concrete gravity dam at A.M.T.M. 63M. on the Barron River which will be of a height sufficient to store at least 320,000 acre feet of water.

(*c*) Existing weirs within the area—namely, Emerald Creek, Dulbil, Granite Creek, Bruce, Leafgold, and Solanum Weir, which will be utilised in the development

of the project to conserve flow of water in the streams on which they are situated and where possible to intercept surplus flows from the main channel system for later utilisation.

(*d*) The proposed works do not include Nullinga Dam the site of which is shown on the plan.—Figure 3.

(ii.) Main Channel Works—

The approximate layout of the main channel works is as shown on the plan —Fig. 3—attached to the report.

The total length of the main channel system is approximately 197 miles and the various lengths and capacities are as shown in Fig. 7 in the report.

The main channel system will consist of various types of channels including trapezoidal section earth and concrete lined, rectangular section reinforced concrete bench flumes, and reinforced concrete pipe lines.

The lengths of the various types of channels are as set out in Table 35 of the report and are also shown in Fig. 7 of the report.

The construction of the main channel system will include numerous structures including regulators, outlets, road and access bridges and culverts, inverted syphons and elevated flumes.

(iii.) Reticulation Systems—

From the main channel systems reticulation or distributary systems of channels and pipe lines will be constructed to deliver water to each farm in the area.

These systems will command an area of some 78,000 acres of farms and will require many miles of channels, the detailed layout of which will be prepared as detailed topographical and soil surveys are available.

As for main channels the reticulation system will consist of open earth, concrete-lined channels, reinforced concrete bench flumes and reinforced concrete pipe lines with the necessary structures including regulators, outlets, road and access culverts.

(d) (i.) Estimate of Total Cost.

The estimated capital cost of the project based on costs as at 30th September, 1951, is £19,130,050 for Tinaroo Falls Dam and all irrigation, drainage, and associated works and £215,000 for the weir at 167M on the Walsh River and the connecting channel from this weir to the South Walsh Main channel, the total cost being £19,345,050.

(ii.) Annual Costs of Maintenance and Management.

The estimated annual costs of maintenance and management of the project after full development and including drainage works based on costs as at 30th September, 1951, exclusive of interest and redemption charges on the capital cost is £164,900.

The estimated annual interest and redemption charges based on 4¾ per cent. of the capital cost of the project is £910,900.

(e) Amount of Money to be Advanced to Commissioner as Loan.

It is not proposed that any money be advanced to the Commissioner as a loan for the construction of the project, but the capital cost shall be met by annual appropriation by Parliament as required.

It is also proposed that the interest and redemption charges on the capital cost of the works shall be met from consolidated revenue and not charged to the Irrigation Area Trust Fund. Any surplus of revenue over operation, maintenance and management costs may, unless required by the Commissioner for further construction works or replacement of works or for payment to a Reserve Fund be paid to the Treasury as a contribution towards interest and redemption charges.

(f) Estimate of Annual Revenue.

The revenue from the project will be derived from water right charges, charges for water sales in excess of water rights, rentals of lands within the irrigation area, drainage charges, and rentals for commission staff houses.

The total estimated annual revenue from all these sources is £287,100 when full development of the project is achieved.

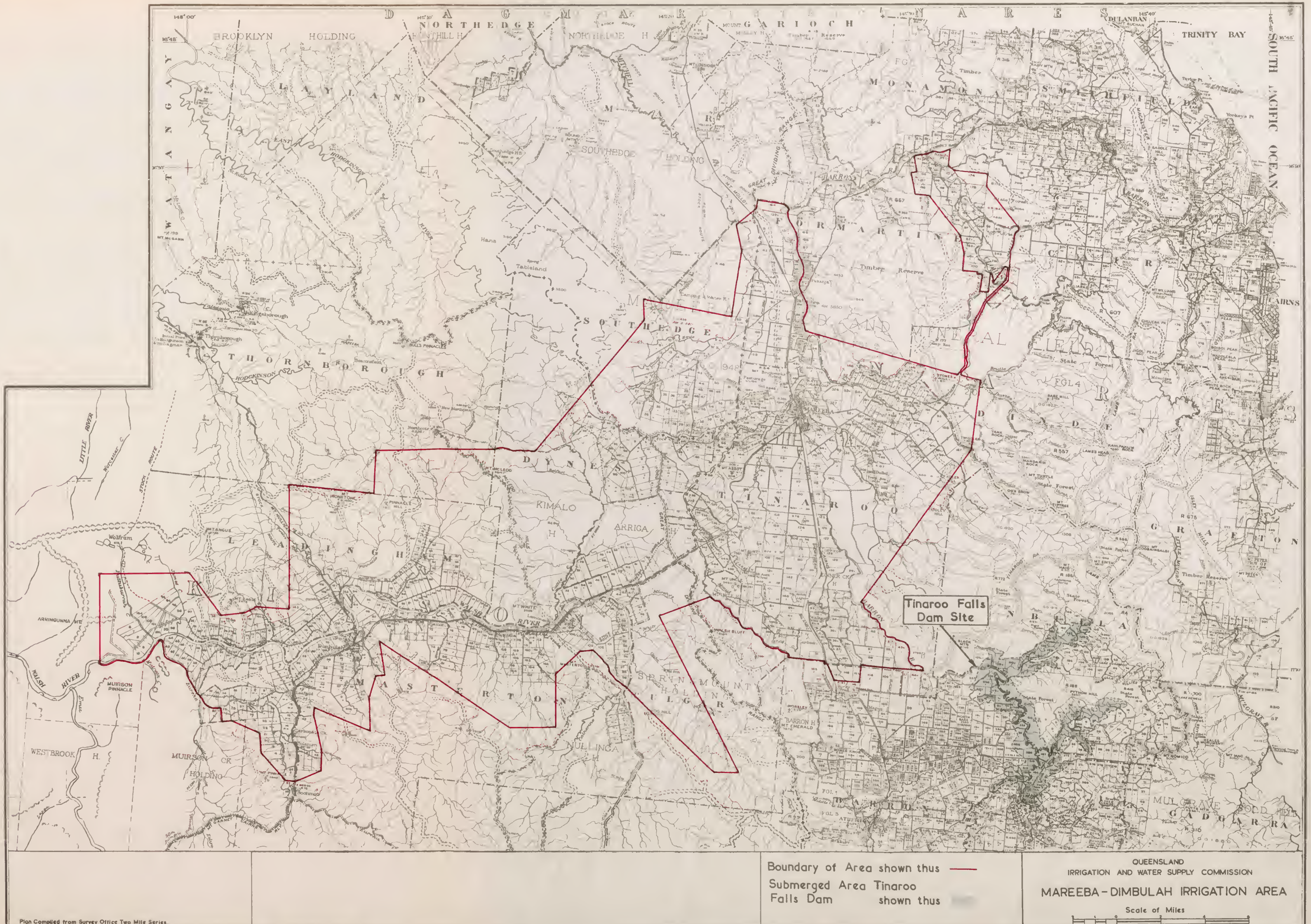
(g) Quantity of Water to be Made Available for Irrigation.

For a storage capacity of 320,000 acre feet in Tinaroo Falls Reservoir the quantity of water to be made available for irrigation in normal and dry years from the storage and at farm boundaries, together with the quantity to be allocated as water rights, is estimated to be as follows:—

——	From storage.	At farms.	Amount allocated as Water Rights.
	acre feet.	acre feet.	acre feet.
Normal years	165,000	82,500	63,450
Dry years ..	101,500	50,750	

(h) Streams over which Commissioner should Exercise Control.

It is proposed that the Commissioner should exercise control over all streams within, entering, or passing through the irrigation area for the purpose of exercising control over the water supply in such streams, for drawing water from such streams for supply to the area and for controlling diversion of water supply from such streams either to lands served by



QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA - DIMBULAH IRRIGATION AREA
Scale of Miles
Boundary of Area shown thus
Submerged Area Tinaroo Falls Dam shown thus
Tinaroo Falls Dam Site
Plan Compiled from Survey Office Two Mile Series
TRINITY BAY
SOUTH PACIFIC OCEAN
CAIRNS
BROOKLYN HOLDING
NORTHEDGE
GARIOCH
MONAMONA
SMITHFIELD
LAYLAND
SOUTHEDGE
FORMARTINE
THORNBOROUGH
DYNE
KIMALO
ARRIGA
TINAROO
LEADINGHAM
MASTERTON
NULLINGA
WESTBROOK
MUIRSON
WALSH RIVER
LITTLE RIVER
DINDEN
GRAFTON
GADGARRA

Fig 1

the irrigation system or to lands not served by the irrigation system and supplied by private diversion from any stream.

(i) Quantity of Irrigable Land to be Irrigated.

The area of land to be contained within farms and classified as irrigable is estimated to be 78,200 acres.

Of this area it is estimated that the water made available for irrigation will enable 37,920 acres to be beneficially irrigated annually.

(j) Description and Value of Irrigable Lands.

The resumption, acquiring, or vesting in the Commissioner of 120,000 acres of land in the project area is expected to be required to permit the resubdivision and development of 68,000 acres of irrigable land as irrigation farms. Some 10,000 acres of land to be classified as irrigable will be situated on existing farms expected to be retained by the present landholders, and not to be resumed.

The present tenure of the lands to be vested in the Commissioner is approximately as follows:—

	Acres.
Reserves	4,000
Special leases	1,000
Occupation licenses	12,000
Mining homestead leases	2,000
Agricultural farms	4,000
Perpetual lease selections	26,000
Holdings	23,000
Vacant	19,000
Freehold	29,000
Total	120,000

The value of the land to be resumed, acquired or vested in the Commissioner for resubdivision and settlement including all improvements is estimated to be £263,900.

W. NIMMO,

Commissioner of Irrigation and Water Supply.

IRRIGATION AND WATER SUPPLY COMMISSION.

14th January, 1952.

The Honourable the Minister for Lands and Irrigation,
Executive Building,
BRISBANE.

Dear Sir,

MAREEBA-DIMBULAH IRRIGATION PROJECT.

I submit herewith a report upon the proposed Mareeba-Dimbulah Irrigation Project, with the recommendation that a dam be built on the Barron River at Tinaroo Falls and works be constructed for the distribution of the water to farms throughout the area.

If the project is approved by the Government, it is recommended that it be submitted to the Commonwealth with the object of its participation, particularly because of the suitability of the project for war service land settlement.

Yours faithfully,

W. NIMMO, Commissioner.

QUEENSLAND

IRRIGATION AND WATER SUPPLY COMMISSION.

MAREEBA-DIMBULAH IRRIGATION PROJECT.

SUMMARY AND RECOMMENDATIONS.

Purpose and Importance of Project

The purpose of the Project is primarily the production of tobacco by irrigation which will lead to the stabilisation and extension of an important industry and a permanent increase in the population of this region of North Queensland.

To reach all the areas of soil suitable for tobacco, channels must pass many areas of soil which are suitable for other crops and provision has been made to supply water to such areas. Sufficient water will also be available for the production of some 66,000 tons of vegetables as rotation crops on tobacco farms. In addition to tobacco, there will therefore be a considerable production of food and other agricultural produce.

Apart from helping to people the North, the Project has a definite value with respect to defence because the soils, on which tobacco will be grown, are very suitable for other crops and the farms could without special preparation be quickly changed over to the production of food or other materials required for the purpose of defence.

War Service Land Settlement.

The intensive cultivation involved in the production of tobacco under irrigation results in a sufficient density of population to permit of the development of social amenities at reasonable cost. Irrigated tobacco growing areas are therefore particularly well adapted to the settlement of war service land settlement trainees who can be given the necessary training on farms already established to ensure their success on a farm of their own.

There is still a considerable number of unsatisfied applicants with war service and the Project will therefore be of great interest to the Commonwealth War Service Land Settlement Authorities.

Necessity for Irrigation.

Almost from the inception of tobacco culture in this region a few growers whose properties are favourably situated on the larger streams, have been able to consistently irrigate their crops and gradual improvement in technique has resulted in demonstrating the great value of the controlled application of water. As the number of tobacco farms increased, the natural flow of the streams proved to be inadequate as a source of water supply and many farmers have had to rely upon growing tobacco by rainfall alone.

The rainfall, however, is irregular in both time of occurrence and in quantity and at least a decade ago it became evident that if the tobacco industry was to be maintained on a large scale and the rapidly-growing population dependent upon it retained in North Queensland, the provision of ample supplies of water for irrigation was essential, particularly with respect to the drier portion of the region west of the Great Divide.

In a report to the Honourable the Minister for Lands following an inspection of the area in 1946, the Bureau of Investigation of Land and Water Resources expressed the opinion that "the retention of a tobacco industry in the Mareeba-Dimbulah area is dependent on the provision of irrigation" and recommended irrigation schemes on the Walsh River and the Mareeba areas. The Bureau further recommended that "the work should cover the design and the estimation of cost of construction of a dam of various heights on the Walsh River at approximately 161 Miles."

In recommending consideration of a dam on the Walsh River, the Bureau was influenced by the fact that, because of lack of topographic information, it was not known at that time that a large quantity of water could be stored on the Barron River or that the waters of that stream could be diverted into the valley of the Walsh River.

Small Storage on Barron River.

In 1939 the possibility of improving the supply of water to the Barron Falls hydro-electric plant by storage at Tinaroo Falls was investigated by the Stanley River Works Board on behalf of the State Electricity Commission. A contour survey was made of the area which would be submerged by a dam 60 feet high at a point known as Bond's Site. The storage capacity of 20,000 acre feet, which would be obtained, was found to be insufficient to bring about any increase in the minimum output of power during droughts.

The building of a higher dam would necessitate the reconstruction on new locations of portions of the railway and several roads, as well as the removal of the village of Kulara. The cost of such reconstruction made any storage of moderate capacity on the Barron unattractive for power generation at that time.

There being no topographic maps of the region prior to the War, it was not possible, except by extensive ground surveys, to determine whether a large storage could be created on the Barron, and in view of the large power generating potential of the Tully River, no further investigation of the Barron was made.

Priority of Use of the Flow of the Barron River for Irrigation.

In 1945 the Co-ordinator-General of Public Works appointed a Committee to investigate "the most advantageous methods of utilising the water resources of North Queensland from the Barron River to the Tully River, having due regard to the requirements for Local Authority purposes and hydro-electric generation." In its report "Water Supply and Hydro-Electric Power, Cairns-Tully Region," the Committee drew attention to the extent to which irrigation was then being practised and indicated that future development was likely to be considerable and that the demand for water for irrigation may be expected to take precedence over the use of water for power generation.

It is now a generally accepted principle in Australia that irrigation shall have priority over power in the use of water.

The proposed diversion of water from the Barron River in the Mareeba-Dimbulah Project will not decrease the present supply of water to the existing Barron Falls hydro-electric plant, although it precludes any increase in the output of power without the provision of additional storage.

Report by the Irrigation and Water Supply Commission, 1949.

Military contour maps, prepared from aerial surveys, having become available, it was discovered that water could be diverted from the Barron River over the Divide into the valley of the Walsh.

In 1949 the Irrigation and Water Supply Commission prepared a report in which it was proposed, as a first stage of the Mareeba-Dimbulah Project, to build a dam at Nullinga, on the Walsh River, and irrigate tobacco lands extending westward from Mareeba down the valley of the Walsh River to a short distance beyond Dimbulah. The second stage comprised a dam of moderate height on the Barron River, at Tinaroo Falls, to provide a supply of water to extend the irrigated area particularly to the east of Mareeba. The dam contemplated in this second stage was the 60 feet high dam already referred to. In accordance with this proposal detailed surveys and investigations were concentrated upon the site of Nullinga Dam and the area that might be irrigated therefrom.

Further Investigations.

Soon after assuming the duties of Commissioner of Irrigation and Water Supply, I made an inspection of the Mareeba-Dimbulah area and the Barron and Walsh Rivers. The earlier investigation, which I had made for the State Electricity Commission, had indicated that the Barron River has a large potential capacity as a source of water supply provided that sufficient storage can be obtained. Examination of the latest military contour map showed that a large reservoir can be created by building a dam at Tinaroo Falls.

I therefore deemed it to be essential, while surveys proceeded in the Walsh area, to also investigate the feasibility of an irrigation scheme supplied from the Barron. An aerial survey, with the necessary ground control, of the area that would be submerged by dams of various heights, was unfortunately delayed by unfavourable weather conditions but it is anticipated that a contour plan of the basin will be available in a few months' time.

A grid survey has been made of the site of the proposed dam and subsurface exploration of the foundation conditions is being commenced. Although it has not been possible to advance surveys on the Barron to the stage reached on the Walsh, a preliminary layout of the scheme has been made and estimates prepared. Pending completion of aerial and other surveys, information has been based mainly on the military maps but there appears to be no doubt that a storage capacity of not less than 320,000 acre feet can be obtained although the exact height of the dam at Tinaroo Falls and its cost cannot yet be determined closely.

ALTERNATIVE SCHEMES.

An irrigated area can be developed in the Mareeba-Dimbulah region with water drawn either from a reservoir on the Walsh River or from a reservoir on the Barron River or from both reservoirs. The irrigation of all land suitable for tobacco and some other land distributed throughout the area, which is suitable for agricultural crops or pasture, will require a total normal annual draft of 215,000 acre feet.

In this report alternative schemes are presented for the development of the area in two stages, each stage including the construction of one dam. The alternative schemes, which differ only with respect to which dam is built in the first stage are:—

Alternative A, comprising—

Stage 1 Nullinga Dam, on the Walsh River, creating a reservoir of 240,000 acre feet capacity, yielding a normal annual draft of 50,000 acre feet, this being the largest dam, which can be economically built at Nullinga; and

Stage 2 Tinaroo Falls Dam, on the Barron River, creating a reservoir of 320,000 acre feet capacity, yielding a normal annual draft of 165,000 acre feet, exclusive of water released to maintain supply to the Barron Falls hydro-electric plant. A larger dam is feasible at this site but is not required for irrigation alone in conjunction with Nullinga Dam.

Alternative B, comprising—

Stage 1 Tinaroo Falls Dam; and

Stage 2 Nullinga Dam.

These alternative schemes are fully described with estimates of cost in this report but a comparison of the principal features is shown in Table A.

CONCLUSIONS.

The following important facts are revealed by an examination of Table A:—

If the project be limited to Stage 1, including only one reservoir, then Alternative B (Tinaroo Falls Dam) has the following advantages compared with Alternative A (Nullinga Dam), viz:—

(1) The location of the reservoir is such that it can command the whole of the area of suitable soils whereas with Alternative A the western portion only can be commanded;

(2) It can provide rather more than three times the quantity of water available from Alternative A at one third of the cost per acre foot of draft;

(3) It will be possible to store some water during the construction of the dam;

(4) The stream flow has been measured over a long period and the quantity of water flowing into the reservoir is known to a high degree of accuracy, whereas with Alternative A, the estimated inflow is based on meagre information and is far less reliable;

(5) It provides for more water per farm than Alternative A;

(6) It provides for approximately twice as many farms, aggregating nearly three times the irrigated area that can be supplied under Alternative A;

(7) Although the total expenditure is approximately fifty per cent. greater than that for Alternative A, the production is nearly twice as great;

(8) The ratio of the value of increased production to expenditure is much greater than for Alternative A.

If both stages of the project be carried out, the total expenditure and the value of increased production will be practically the same for Alternatives A and B. For the two stages the annual value of production will be £6,452,000, but of this £6,161,000, or 95 per cent., can be obtained from Tinaroo Falls Dam and the first stage only of Alternative B. Tinaroo Falls Dam alone can supply the whole of the tobacco farms, and consequently the expenditure of some £8,000,000 on Nullinga Dam and additional irrigation works, either as a first or second stage of a combined project, will increase the ultimate annual value of production by less than £300,000 derived from 152 mixed agricultural and pasture farms on soils not suitable for tobacco.

The additional 50,000 acre feet required annually to irrigate these 152 farms, can—assuming the military contour map to be reliable—be obtained by increasing the height of Tinaroo Falls Dam by 20 feet, creating a reservoir of 520,000 acre feet storage capacity, for an additional expenditure of some £2,780,000.

The outstanding advantages of Alternative B (Tinaroo Falls Dam) enumerated above are considered to outweigh the following disadvantages:—

(*a*) A deviation of the railway between Kairi and Yungaburra will be necessary and several roads will have to be reconstructed on new locations;

(*b*) The area that will be submerged by Tinaroo Falls Dam includes some 5,200 acres of valuable farm land whereas that which would be submerged by Nullinga Dam is grazing land of low value;

(*c*) The concrete dam proposed at Tinaroo Falls will require more cement than would be needed for an earth dam at Nullinga although the latter would require a considerable quantity of cement in the spillway and diversion tunnel;

(*d*) Because of the necessity of completing surveys and exploring foundation conditions at the site of Tinaroo Falls Dam, there will be some delay in commencing construction of the dam. In compiling the estimates of annual expenditure and return contained in this report, it was assumed that construction at Tinaroo Falls would commence two years later than at Nullinga. This is a conservative assumption and is largely offset by the fact that the concrete dam proposed at Tinaroo Falls will lend itself to supplying water during construction, the rate of supply increasing as the work progresses,

whereas this would be very difficult and expensive at Nullinga. Moreover the construction of a weir on the Walsh River near Nullinga, which can be utilised as a regulating pond in the completed project, will provide a limited supply to farms on the left bank of the Walsh River which are most in need of such supply. Production should therefore proceed as rapidly with Alternative B as with Alternative A.

PROVISION FOR SUPPLY OF WATER DURING CONSTRUCTION OF DAM.

Supply of Water from a New Weir on Walsh River.

At 167 A.M.T.M. on the Walsh River, about six miles upstream from the site of the proposed Nullinga Dam, there is a suitable site for the construction of a weir, 30 feet high, impounding 840 acre feet of water. It is proposed that this weir, an access road to the weir, and a connecting channel from the weir to the South Walsh Main Channel be built at an estimated cost of £215,000, and that a section of the South Walsh Main Channel be constructed at the same time to convey water impounded by the weir to farms in the Horse Creek and adjacent areas.

This temporary supply will meet the most urgent needs of the Walsh area until full supply can be delivered from the Barron.

Early Supply to Granite Creek Area.

Early development in the Granite Creek and Atherton Creek areas is proposed by constructing sections of the West Barron Main, the Mareeba Main, and Atherton Creek Lateral to convey water which may be impounded by Tinaroo Falls Dam while it is being built.

HYDRO-ELECTRIC POWER.

It may be found possible to generate some electric power from the water discharged from Tinaroo Falls Dam for irrigation by installing small plants at points on the channels where surplus fall exists. The power so generated will be small in quantity and intermittent and its value will be low. The installation of such generating plants will be considered when detail plans are being prepared.

The available head below Barron Falls is approximately twice that under which the existing plant operates. A considerable increase in the output of power would be possible, if a larger and more regular supply of water could be provided. The possibility of ultimately raising Tinaroo Falls Dam, beyond the height required for irrigation alone, for the purpose of supplying more water to the Barron Falls plant, in conjunction with a dam on Flaggy Creek, should not be overlooked. Such a development will not be required in the immediate future but the necessary investigation, including an aerial survey of Flaggy Creek, should be made now.

RECOMMENDATIONS.

It is recommended that—

(1) The proposal to build a dam at Nullinga on the Walsh River be deferred indefinitely since it will not be needed until such time as all available water must be conserved;

(2) Approval be given to the construction of a dam at Tinaroo Falls on the Barron River to have a storage capacity of not less than 320,000 acre feet. A definite decision regarding the precise location of the dam and its initial and ultimate height and cost must await completion of surveys and foundation exploration;

(3) Sections of the West Barron Main, Mareeba Main Channels, and Atherton Creek Lateral be constructed concurrently with the building of Tinaroo Falls Dam;

(4) A weir on the Walsh River at 167 A.M.T.M. to impound 840 acre feet of water be constructed immediately;

(5) A section of the South Walsh Channel be constructed concurrently with the building of the weir;

(6) The remainder of the project including main and reticulation channels and pumping stations be carried out continuously until completed and farms developed concurrently.

If the storage capacity of Tinaroo Falls Reservoir be limited to 320,000 acre feet, the project covered by the foregoing recommendations will be identical with Stage 1 of Alternative B except for the addition of the proposed new weir on the Walsh River, the cost of which will not appreciably affect the figures shown in Table A.

In the event of the surveys and foundation explorations, now being carried out, indicating that an increase in the storage capacity of Tinaroo Falls Reservoir is economically feasible, this will be the subject of a further recommendation.

FINANCING PROJECT.

As stated in the report, experience with large irrigation schemes in other States has shown that it is usually necessary for the Government to meet all annual charges other than those with respect to maintenance, operation and administration. Because of the high value of production from tobacco, it is expected that direct revenue from the proposed Mareeba-Dumbulah Project will be sufficient to make some contribution towards annual capital charges but it is considered essential that the remainder of such charges be met by the State or State and Commonwealth together, both of which will receive a substantial indirect return from the Project.

W. H. R. NIMMO,
M.C.E., M.I.C.E., M.Am.Soc.C.E., M.I.E.Aust.,
Commissioner of Irrigation and Water Supply.

TABLE A.

—	Alternative A.	Alternative B.
Storage Stage 1	Nullinga Dam on Walsh River.	Tinaroo Falls Dam on Barron River
Catchment area, sq. miles	124	220
Average annual rainfall, inches	42·6	54·4
Capacity of proposed storage, acre feet	240,000	320,000
Normal annual draft available for irrigation, acre feet	50,000	165,000
Cost of storage, total	£7,166,000	£7,830,000
Cost of storage per acre feet of capacity	£29·8	£24·5
Cost of storage per acre feet of normal annual draft	£143	£47·5
Stage 1 of Proposed Scheme—		
Farm openings commence	1956–57	1958–59
Farm openings completed	1962–63	1968–69
Number of tobacco farms	768	1,180
Number of mixed agriculture farms	..	240
Number of pasture farms	..	..
Total number of farms	768	1,420
Total area irrigated per annum, acres	12,288	37,920
Estimated total capital expenditure	£13,387,850	£19,130,050
Estimated total expenditure, including working expenses, to date of completion of works and farms	£13,766,095	£20,138,194
Value of increased production	£3,207,800	£6,161,000
Annual return reckoned as 40 per cent. of value of increased production	£1,283,120	£2,464,400
Annual return as per cent. of total expenditure	9·3%	12·2%
Present value of annual return as per cent. of present value of expenditure, taking interest at 4½ per cent.	29·6%	54·4%
Stages 1 and 2 of Proposed Scheme—		
Additional storage for Stage 2	Tinaroo Falls Dam on Barron River	Nullinga Dam on Walsh River
Farm openings completed	1967–68	1969–70
Number of tobacco farms	1,180	1,180
Number of mixed agriculture farms	333	333
Number of pasture farms	59	59
Total number of farms	1,572	1,572
Total area irrigated per annum, acres	47,540	47,540
Estimated total capital expenditure	£26,327,400	£27,154,400
Total expenditure, including working expenses	£27,431,625	£28,353,754
Value of increased production	£6,452,200	£6,452,200
Annual return reckoned as 40 per cent. of value of increased production	£2,580,880	£2,580,880
Annual return as per cent. of total expenditure	9·4%	9·1%
Present value of annual return as per cent. of present value of expenditure, taking interest at 4½ per cent.	48·1%	48·0%

MAREEBA-DIMBULAH IRRIGATION PROJECT.

PART I.—GENERAL REPORT.

DESCRIPTION OF AREA.

The area, which is covered by this report and is shown on the Locality Map (Fig. 1), is traversed by two principal streams. Some 20 miles to the west of Cairns, the Barron River flows in an almost due northerly direction to a point a few miles north of Biboohra where it turns sharply to the eastward and, after breaking through the coastal range by the Kuranda Gorge, empties into the Pacific Ocean near Cairns. About 10 miles further west, the Walsh River also flows almost due north to a point where it turns abruptly to the west, flowing thence past Dimbulah to join the Mitchell River draining into the Gulf of Carpentaria. These two rivers with their tributaries are the only sources of surface water supply in the area. Separating the two streams is the Great Divide which forms a range only in the southern portion of the area but in the northern portion is merely a narrow strip of flat land between the Barron and a branch of the Mitchell Rivers.

HISTORY OF TOBACCO GROWING.

In 1927 the Commonwealth Government, working through the Australian Tobacco Investigation Board (a Commonwealth body) in conjunction with the State Department of Agriculture and Stock, decided to explore the commercial prospects of tobacco cultivation in North Queensland. Some 30 experimental plots were established and results were so encouraging that an experimental farm was established near Mareeba in the following year. Eight acres were planted with tobacco and good results were obtained.

Commercial production in the Mareeba-Dimbulah district may be said to have begun in 1929-30 when a settlement of 26 farms was established at Chewko on Granite Creek some 7½ miles south-west of Mareeba (Fig. 1). Seasons were favourable and more farmers were attracted to the district. There was a rapid expansion, principally in the valleys of the Barron River and Emerald Creek, as shown by the number of pumping licenses in force each year (Table 1) but there was considerable increase in tobacco growing under irrigation on other tributaries of the Barron. The development in this area was due to the perennial nature of the streams.

From 1940 onwards there was also a steady increase in the number of irrigated tobacco farms in the Walsh area, particularly along the Walsh River itself, but development was less extensive in this region due to poorer water supply resulting from an average annual rainfall ranging from only 36 inches at the western end of the area to less than 26 inches at Dimbulah.

TABLE 1.

NUMBER OF PUMPING LICENSES IN FORCE ON VARIOUS STREAMS IN EACH YEAR.

Year.	Walsh River and Tributaries.							Barron River and Tributaries								
	Total.	Walsh River.	Cattle Creek.	Horse Creek.	Sandy Creek.	12 Mile Creek.	Eureka Creek.	Total.	Barron River.	Atherton Creek.	Granite Creek.	Tinaroo Creek.	Emerald Creek.	Clohesy River.	Davies Creek.	Rocky Creek.
1928	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..
1929	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..
1930	..	..	..	..	..	..	..	1	..	..	1	..	..	..	..	..
1931	..	..	..	..	..	..	..	3	..	..	1	..	2	..	..	..
1932	..	..	..	..	..	..	..	10	7	..	1	..	2	..	..	..
1933	..	..	..	..	..	..	..	10	7	..	1	..	2	..	..	..
1934	..	..	..	..	..	..	..	13	7	..	1	..	5	..	..	..
1935	1	1	..	..	..	..	..	27	8	..	2	..	17	..	..	..
1936	2	2	..	..	..	..	..	40	10	1	5	2	22	..	..	..
1937	6	6	..	..	..	..	..	52	15	3	6	2	26	..	..	..
1938	6	6	..	..	..	..	..	59	17	4	6	5	27	..	..	..
1939	8	8	..	..	..	..	..	67	21	4	8	5	28	1	..	..
1940	14	14	..	..	..	..	..	71	25	4	8	5	28	1	..	..
1941	29	25	1	3	..	..	..	77	29	6	8	5	28	1	..	..
1942	35	30	1	3	..	..	1	79	30	6	8	6	28	1	..	..
1943	39	34	1	3	..	..	1	87	31	6	10	6	30	3	1	..
1944	54	42	1	3	2	1	5	86	30	7	12	6	27	3	1	..
1945	52	40	1	2	3	1	5	96	33	7	13	7	27	8	1	..
1946	58	44	1	4	3	1	5	105	38	7	15	8	27	9	1	..
1947	62	49	1	3	3	1	5	124	48	8	20	8	27	11	2	..
1948	64	51	1	3	3	1	5	132	51	8	22	8	29	12	2	..
1949	65	52	1	3	3	1	5	143	56	8	23	8	31	13	2	2
1950	67	54	1	3	3	1	5	159	64	9	27	9	32	12	2	3
1951	72	59	1	3	3	1	5	170	69	10	27	10	36	13	2	3

TABLE 2.

TOBACCO PRODUCTION IN THE MAREEBA-DIMBULAH AREA.

Year.	Number of Growers.	Acres planted.		Production in lb.			Average value per lb.
		Total.	Per grower.	Total.	Per acre.	Per grower.	s. d.
1932–33	800	2,227	2·78	1,046,571	469	1,308	1 3
1933–34	400	1,258	3·14	553,253	440	1,384	1 4
1934–35	..	2,053	..	1,051,308	500	..	1 9½
1935–36	513	2,714	5·29	1,173,605	432	2,092	1 7½
1936–37	..	2,513	..	1,454,784	578	..	1 8½
1937–38	393	2,222	5·65	1,174,043	527	2,987	1 7
1938–39	..	2,800	..	1,403,107	500	..	1 10
1939–40	388	3,242	8·35	1,644,509	506	4,238	2 3
1940–41	..	3,200	..	1,334,954	417	..	2 5
1941–42	349	3,200	9·16	1,707,552	532	4,892	2 8
1942–43	278	3,046	10·95	1,692,544	556	6,088	2 10
1943–44	170	1,399	8·22	1,039,808	742	6,116	2 8
1944–45	148	1,205	8·14	777,728	645	5,254	2 5
1945–46	141	1,208	8·56	791,168	656	5,611	2 8
1946–47	155	1,367	8·81	1,036,560	840	6,687	2 8
1947–48	135	1,233	9·13	1,033,312	838	7,654	3 6
1948–49	116	1,015	8·75	916,160	901	7,897	5 1
1949–50	170	1,713	10·07	1,530,189	893	9,001	6 7
1950–51	184	2,418	13·14	1,350,890	559	7,341	9 3

Statistics relative to the number of growers, areas planted, and the quantity of tobacco leaf produced, which are available only for 1932-33 and later seasons, are shown in Table 2.

In the 1932-33 season there were no less than 800 growers with an average planted area of 2¾ acres each. The average production of 469 lb. per acre was not appreciably improved upon till 1941-42. Insufficient production from small areas, together with the low price of 1s. 3d. per lb., put the poorer growers out of business and only half of the original 800 survived till the next season. Heavy rain in November, December, and January was probably responsible for a reduced yield in 1933-34. The number of growers fluctuated around 400 until 1939-40, when the area per grower had increased to 8⅓ acres and the price had risen to 2s. 3d. per lb.

During the war and subsequent years the number of growers decreased steadily to 116 in 1948-49, but the total area planted was maintained around 3,000 acres till 1942-43, after which it declined to a minimum of 1,015 acres in 1948-49, notwithstanding that the price had risen to 5s. 1d. per lb. The decline in the number of growers was partly due to the demand for vegetables during this period. The 1948-49 season was specially favourable, there being only 3¾ inches of rain during the last three months of 1948, and production reached a maximum of 901 lb. per acre. This satisfactory crop attracted more growers, who by 1950-51 had increased to 184 and the area per grower to 13·14 acres. At the then ruling average price of 9s. 3d. per lb., tobacco growing had become a lucrative business but was still subject to the vagaries of the climate.

The experience of some twenty years of tobacco growing in North Queensland, particularly in the Mareeba-Dimbulah area, has demonstrated not only the benefit of but the necessity for irrigation in maintenance of a stable and valuable industry. For production of the greatest quantity and the finest quality of leaf, it is essential that moisture in the soil be maintained within certain optimum ranges from planting to harvesting. Excessive humidity or too much rain are as inimical to the plant as is drought since they are conducive to the development of mould diseases, or plant deterioration resulting from excessive soil moisture. The rainfall during the three months October, November, and December, 1950, of 5·87 inches at Mareeba and 14·20 inches at Dimbulah reduced the output of leaf per acre to almost half of that of the favourable light rainfall season of 1948-49. A farmer growing tobacco by natural rainfall may, if he plants early, see his crop wither because the early summer storms are late or absent or, if he plants late, find his crop ruined by disease or plant collapse during the wet months of the monsoon. Usually tobacco to be grown by natural rainfall is planted in November and harvested in February. Under irrigation, planting may be done in August or September and harvesting completed before the onset of the wet weather. A glance at Table 2 shows that during the eleven seasons 1932-33 to 1942-43 there was only a slight upward trend in annual production which averaged about 500 lb. per acre. The gradual adoption of irrigation then brought about a marked upward trend. This improvement in the average production may be attributed largely to increase in the use of irrigation.

This expansion is evident from an inspection of Table 1 showing the number of pumping licenses in force in the tobacco-growing areas at the close of each year. There are now nearly two and one half times as many pumping licenses in the drainage area of the Barron than there are in that of the Walsh because the flow in the Barron and its tributaries, which rise in forest or jungle covered areas, is better sustained than that in the tributaries of the Walsh which, because of lower rainfall, often cease to flow for portion of the year.

After an inspection of the area in 1946, the Bureau of Investigation of Land and Water Resources submitted a report to the Hon. The Minister for Lands, which concluded with the following summary:—

"Summarising, it may be said that the retention of a tobacco industry in the Mareeba-Dimbulah area is dependent on the provision of irrigation. Owing to the many unfavourable

features of the terrain, the provision and application of irrigation water will be costly and only a fraction of the costs could be borne directly by the farmers. At the same time, it is considered that water conservation and distribution proposals for this area should not be assessed solely on the immediate and direct increase in production therefrom.

"It is both desirable and necessary to intensify the settlement of North Queensland. Moreover, a lot of capital, labour, and hope has been invested in the Mareeba-Dimbulah tobacco venture and there is every indication that this investment is disappearing. No time is to be lost; growers have been discouraged and a mass exodus is not only a possibility but a distinct probability."

The serious position presented by the Bureau has been to some extent alleviated by the construction by the Irrigation and Water Supply Commission of a number of weirs, but, useful as they have proved to be, such weirs are a palliative rather than a cure for the shortage of water. Realising that large storages are essential, particularly for the irrigation of the lower rainfall areas in the Walsh drainage area, the Bureau in its report recommended:—

". . . . an immediate determination of the cost and capacities of complete irrigation schemes on the Walsh River and in the Mareeba areas which would provide for the irrigation of tobacco and other lands in the manner indicated in this report. The work should cover the design, and the estimation of cost of construction, of a dam of various heights on the Walsh River at approximately 161 miles."

IRRIGATION DEVELOPMENT INVOLVING STORAGE ON THE WALSH RIVER.

Subsequent to the report by the Bureau of Investigation a thorough examination of the Walsh River by the Irrigation and Water Supply Commission disclosed that the only feasible site for a dam is at Nullinga at 161.3 miles where the river breaks through a spur of the Dividing Range between Wog Hill and Mt. Masterton. A contour survey by aerial methods of the area that would be submerged together with a hydrological investigation of the catchment area has revealed that the economic limit for a dam at this site would be one impounding water to a depth of 148 feet and creating a reservoir having a storage capacity of 240,000 acre feet. Such a reservoir will control the greater portion of the runoff from the catchment area and provide for a normal annual draft of 50,000 acre feet which will suffice for the irrigation of most of the land suitable for tobacco on both sides of the Walsh River as far west as Eureka Creek some miles downstream from Dimbulah and also for an area (Fig. 2) extending eastwards to Granite Creek and northwards to a line about two miles north of Mareeba.

The development of this area having been tentatively decided upon, detailed surveys were commenced and pushed ahead as rapidly as the limited technical staff available would permit. Contour surveys have now progressed to a stage which permits the general location of irrigation channels and the dam site has been explored by diamond drilling and shaft sinking. Concurrently with ground surveys, the area was covered by aerial photography and a reconnaissance soil survey was carried out by officers of the Bureau of Investigation.

IRRIGATION DEVELOPMENT INVOLVING STORAGE ON THE BARRON RIVER.

As long ago as 1924 in a report to the Cairns Hydro-Electric Power Investigation Board on the "Development and Utilisation of the Power of the Barron Falls," Wm. Corin, M.Inst.C.E., directed attention to the possibility of building a dam at Tinaroo Falls on the Barron River situated about eight miles north-east of Atherton, but because of inaccuracy of the barometric levels then available, the actual site proposed by him was subsequently found to be unsuitable.

In 1939 the possibility of improving the supply of water to the Barron Falls hydro-electric plant by storage at Tinaroo Falls was investigated by W. H. R. Nimmo, Chief Engineer, Stanley River Works Board, on behalf of the State Electricity Commission. In his report, based upon a contour survey of the area which would be submerged by a dam, at a point known as Bond's Site, 60 feet high (spillway level R.L. 2125)—that being the greatest depth to which water could be impounded without considerable interference with roads and railway—it was shown that the available storage capacity of 20,000 acre-feet would be insufficient to increase the minimum flow of the river during extreme droughts and no further action was taken at that time.

It was not until after the War, when military contour maps, produced from aerial surveys, became available, that it was discovered that it is possible to divert water from the Barron River at Tinaroo Falls into the Walsh River. Although the military maps have not the degree of accuracy necessary for an adequate investigation of an irrigation project, they sufficed to show that a much larger dam could be built at Tinaroo Falls and that the roads and railway affected could be satisfactorily relocated. It was therefore proposed that storage on the Barron River and extension of the irrigated area would constitute Stage 2 of the Mareeba-Dimbulah Project and that investigation should continue to be concentrated on the Walsh area.

The Barron River at Tinaroo Falls, because of its larger catchment and greater rainfall and elevation which can command the whole area from the Clohesy River on the east to Eureka Creek on the west and beyond Biboohra to the north, appeared attractive as a main source of supply because it can alone provide enough water to develop most of the area. Although it has not been possible to carry out exploratory drilling on possible dam sites nor to advance surveys on the Barron to the stage reached on the Walsh, investigations made during the last two years, based upon available surveys, supplemented by information contained in military contour maps and records of actual stream flow over a period of 37 years, have resulted in a general design of an irrigation scheme supplied with water from the Barron.

Although the approximate military contours indicate that a higher dam is possible, the minimum economic height for Tinaroo Falls Dam appears to be one impounding water to a depth of 133 feet (R.L. 2193) and creating a reservoir having a storage capacity of 320,000 acre feet which will provide for a normal annual draft of 165,000 acre feet. Water will be released from Tinaroo Falls reservoir as may be necessary to maintain the flow at Barron Falls hydroelectric plant equal to what it would be if no dam existed up to a total flow of 212 cusecs which is the maximum required by the existing plant. This has been allowed for in estimating the normal annual draft of 165,000 acre feet for irrigation.

ALTERNATIVE SCHEMES.

Alternative proposals are presented for ultimate maximum irrigation development in two stages. The first stage will be either—

(A)—Irrigation of the western or Walsh River portion of the area by supply from Nullinga Dam, on the Walsh; or

(B)—Irrigation of portion of the drainage areas of both the Barron and Walsh Rivers by supply from Tinaroo Falls Dam, on the Barron.

In either case the first stage may be regarded as a complete scheme in itself.

The revenue and volume of production from the two stages combined will be the same whichever scheme is adopted as the first stage, but the ultimate capital investment will be slightly higher in the case of alternative B.

Descriptions and estimates of cost for the alternative combinations are given below.

Alternative A—Stage 1: Nullinga Dam; Stage 2: Tinaroo Falls Dam.

Stage 1.

This stage comprises construction of Nullinga Dam, on the Walsh River, and main channels on both sides of the Walsh, together with the necessary reticulation channels to convey water by gravity for the irrigation of land on both sides of the Walsh westward to Eureka Creek and northwards towards Mareeba, the commanded area being shown in green on the plan (Fig. 4), and the layout of main channels on the plan (Fig. 2). Since Nullinga Dam cannot supply sufficient water for all land in the area served by the channels, development in this stage for economical reasons would be restricted to those soils suitable for growing tobacco and the water right would be limited to ½ acre foot per acre which, with an allowance of 30 per cent. additional water by sale, represents a supply to the average 50-acre farm of 32.5 acre feet in normal years. Approximately 768 farms would be irrigated.

Stage 2.

This stage comprises the construction of Tinaroo Falls Dam, on the Barron River, and main and distributory channels to serve areas on Granite, Atherton, Tinaroo, and Emerald Creeks and the Clohesy River, together with an area on the left bank of the Barron adjacent to Biboohra, the area of mainly basaltic soils between the Barron River and Atherton Creek, to the south of Mareeba, and an extension below 5 Mile Creek of the area commanded on the right bank of the Walsh River.

In this stage, land above the channel levels in Paddy's Green, Nardello's Lagoon, and Springmount areas would be developed by pumping. The additional area commanded by this stage is shown in red on the plan (Fig. 4), and the layout of the main channel system in the plan (Fig. 2). The additional water available would permit of increasing the water right to the original farms in Stage 1 to ¾ acre foot per acre, thus allowing for an increase in the area of crops grown on each farm.

In addition to serving 412 new tobacco farms in the Stage 2 area, a supply would be provided to 333 mixed agricultural farms and 59 pasture farms on soils suitable for those purposes distributed throughout the areas of Stages 1 and 2. The channels in Stage 1 would be constructed of sufficient size to carry the additional water that would be available from Tinaroo Falls Dam and an amount of £1,370,000 has been included in the estimate of cost for Stage 1 for the additional size of channels necessary to provide for Stage 2 requirements.

Alternative B—Stage 1: Tinaroo Falls Dam; Stage 2: Nullinga Dam.

Stage 1.

This stage comprises construction of Tinaroo Falls Dam on the Barron River, and main and reticulation channels to serve the areas supplied by the storage. The quantity of water available would be sufficient to permit of extending channels throughout the whole of both the Barron and Walsh areas shown in green on the plan (Fig. 5) and supplying water to all tobacco and 240 mixed agriculture farms. Because of greater length of channels, this stage will take longer to construct than will Stage 1 of Alternative A and will involve some £5,740,000 additional capital expenditure.

In order to supply existing farms on the left bank, Walsh area, as soon as possible, a special channel extension (Walsh Bluff Main) would be provided to supply the South Walsh Main from the West Barron Main via Walsh Bluff and a syphon at Nullinga Dam site. In other respects the channel system would be similar to the completed channel system of Alternative A and pumping would be necessary to high level channels in the Paddy's Green and Nardello's Lagoon areas as for Alternative A, but supply to the Springmount area would be by gravity.

The channel layout for this stage is shown in the plan (Fig. 3).

Stage 2.

This stage comprises the construction of Nullinga Dam, on the Walsh River, which in normal years will supply 50,000 acre feet of water. This would not result in an extension of the area already commanded by the main channel system, but 152 additional farms would be served, comprising 93 mixed agriculture and 59 pasture farms of a total area of 19,240 acres, of which 9,620 acres would be irrigated annually.

The location of these additional areas is shown hatched red on the plan (Fig. 5).

Nature and Extent of Development.

Details of numbers and types of farms, areas, water allocations, and areas irrigated for the two alternative schemes are set out in Table 3.

TABLE 3.

NATURE AND EXTENT OF DEVELOPMENT.

Stage.	Farm type.	Alternative A.						Alternative B.					
		Number of farms.	Average area per farm	Total area of farms.	Water right allocation.	Total water available per farm per annum	Area irrigated per annum.	Number of farms.	Average area per farm.	Total area of farms.	Water right allocation	Total water available per farm per annum	Area irrigated per annum.
			acres.	acres.	acre feet per acre.	acre feet.	acres.		acres.	acres.	acre feet per acre.	acre feet.	acres.
1 ..	Tobacco	768	50	38,400	½	32·5	12,288	1,180	50	59,000	¾	48·7	28,320
	Mixed agriculture	..	..	..	..	..	..	240	80	19,200	1	104	9,600
Total Stage 1		768	..	38,400	..	..	12,288	1,420	..	78,200	..	..	37,920
1 and 2	Tobacco	1,180	50	59,000	¾	58·7	28,320	1,180	50	59,000	¾	48·7	28,320
	Mixed agriculture	333	80	26,640	1	104	13,320	333	80	26,640	1	104	13,320
	Pasture	59	200	11,800	1	260	5,900	59	200	11,800	1	260	5,900
Total Stages 1 and 2 ..		1,572	..	97,440	..	..	47,540	1,572	..	97,440	..	..	47,540

Capital Cost.

The estimated capital cost of the whole project based on costs as at 30th September, 1951, is shown in Table 4 for the two alternative schemes.

TABLE 4.

ESTIMATE OF CAPITAL COST.

—	Alternative A.		Alternative B.	
	Stage 1.	Stage 2.	Stage 1.	Stage 2.
	£	£	£	£
Storage	7,166,000	7,830,000	7,830,000	7,166,000
Main channels	3,070,000	1,530,000	5,400,000	..
Irrigation works	1,996,800	2,078,200	3,640,000	435,000
Drainage works	499,200	767,500	1,016,600	250,100
Pumping stations	..	91,000	78,000	..
Office and staff accommodation	133,750	98,750	204,750	27,750
Roadworks, land resumptions and surveys	522,100	544,100	960,700	145,500
Totals	13,387,850	12,939,550	19,130,050	8,024,350
Totals Stages 1 and 2	26,327,400		27,154,400	

Annual Capital Charges.

Assuming interest at 4⅛ per cent. and redemption at ⅝ per cent., the annual charges on account of interest and redemption will be as shown in Table 5 for the two alternative schemes.

TABLE 5.

ESTIMATE OF ANNUAL CAPITAL CHARGES.

—	Loan period.	Alternative A.		Alternative B.	
		Stage 1.	Stage 2.	Stage 1.	Stage 2.
	years.	£	£	£	£
Storages	50	340,400	371,900	371,900	340,400
Main channels	50	145,800	72,700	256,500	..
Irrigation works	50	94,900	98,700	172,900	20,700
Drainage works	50	23,700	36,500	48,300	11,900
Pumping stations	50	..	4,300	3,700	..
Office and staff accommodation	50	7,900	5,800	12,000	1,700
Road works, land resumptions and surveys ..	50	24,800	25,800	45,600	6,900
Totals	..	637,500	615,700	910,900	381,600
Totals Stages 1 and 2		1,253,200		1,292,500	

If adequately maintained dams and unlined earthen channels have an extremely long life. Irrigation channels which are lined with concrete may require renewal of the lining at up to 50 years.

Annual Working Costs.

Operation, Maintenance, and Administration.

The estimated annual costs of operation, maintenance and administration are shown in Table 6 for the two alternative schemes.

TABLE 6.

ESTIMATE OF ANNUAL WORKING COSTS.

—	Alternative A.		Alternative B.	
	Stage 1.	Stage 2.	Stage 1.	Stage 2.
	£	£	£	£
Storages, main channels, irrigation works, and pumping stations— Operation, maintenance, administration	64,600	78,300	125,800	16,700
Drainage— Operation, maintenance, administration	19,200	29,500	39,100	9,600
Total	83,800	107,800	164,900	26,300
Total Stages 1 and 2	£191,600		£191,200	

The annual cost of operation, maintenance and administration in respect of drainage works has been estimated at 10s. per acre on the area of all farms.

Revenue.

It is not possible in any large irrigation project to meet all annual charges from direct revenue. Charges for water and drainage must be fixed at rates which the farmers can reasonably be expected to meet. For the Mareeba-Dimbulah Project it is considered that the rates set out in Table 7 below are well within the capacity of farmers to pay, having regard to the value of the kind of crop grown. The differential rates suggested have been arrived at, after consideration of the frequency of irrigation service required for the various forms of land use and of the probable income from each of the various types of farm, with a view to establishing a reasonably close relationship between total charges and income per farm as indicated in Table 7.

It is also proposed that the charge for water be uniform for areas supplied by gravity and those supplied by high level channels to which water must be pumped from low level channels. Costs of pumping have been included in the operation and maintenance costs set out in Table 6.

TABLE 7.

ALLOCATION OF WATER, PROPOSED WATER CHARGES AND ESTIMATED GROSS VALUE OF PRODUCTION PER FARM.

Type of farm.	Average farm area.	Water right allocation.		Water charge per acre feet water right and sales.	Total annual water charge for average farm area and water right plus sales.	Estimated gross annual value of production.
		Acre feet.	Maximum volume.			
	Acres.	per acre.	Acre feet.	£ s. d.	£ s. d.	£
Tobacco	50	½	Up to 70 ..	3 10 0	113 15 0	4,600
Tobacco	50	¾	Up to 70 ..	3 10 0	170 12 6	5,400
Mixed agriculture	80	1	Up to 140 ..	1 10 0	156 0 0	2,400
Pasture	200	1	Over 140 ..	1 0 0	260 0 0	2,000

If the supply of water is restricted at all times to that which can be delivered to farms even during the worst droughts, there will be considerable wastage of water in good seasons. It is in the interest of farmers to get the maximum production from their farms and this can only be achieved by varying the total quantity of water to be supplied during any year according to the nature of the season and the state of the reservoirs. In accordance with usual practice, the water right has been fixed at that quantity of water which can be safely supplied in the majority of years. In normal years the farmer may purchase additional water up to 30 per cent. of the water right at the same rate per acre foot as that applicable to the water right. During extreme droughts the supply of water may have to be restricted but such restricted supply will not be less than 80 per cent. of the water right.

For the purpose of estimating annual revenue on a somewhat conservative basis, it has been assumed that on the average there will in each ten year period be—

- 2 years 80 per cent. Water rights (restricted supply);
- 2 years Water rights only (low demand in wet years);
- 6 years Full water deliveries, i.e., water rights plus 30 per cent. sales (normal years).

Table 8 shows the balance of annual capital charges after deduction of surplus revenue over working costs.

TABLE 8.

ESTIMATE OF ANNUAL REVENUE AND COSTS.

Alternative A.				Alternative B.			
Annual revenue.	Annual working costs.	Surplus of revenue over working cost.	Balance of annual capital charges after deduction of surplus of revenue over working costs.	Annual revenue.	Annual working costs.	Surplus of revenue over working cost.	Balance of annual capital charges after deduction of surplus of revenue over working costs.
£	£	£	£	£	£	£	£
Stage 1— 115,100	83,800	31,300	606,200	287,100	164,900	122,200	788,700
Stages 1 and 2 329,900	191,600	138,300	1,114,900	329,900	191,200	138,700	1,153,800

Production.

The project being designed primarily to assist and expand the tobacco industry in North Queensland, the greater portion of the total value of production will be derived from tobacco leaf, the estimated average annual output being shown in Table 9.

TABLE 9.

ESTIMATED TOBACCO PRODUCTION.

——	Alternative A.	Alternative B.
	Lb.	Lb.
Stage 1	7,680,000	11,800,000
Stages 1 and 2	11,800,000	11,800,000

The estimated total value of production from the project and increased value of production after allowing for existing production from the area to be developed and loss of production from the area to be submerged by Tinaroo Falls Reservoir at each stage is shown in Table 10.

TABLE 10.

ESTIMATED VALUE OF PRODUCTION.

——	Alternative A.	Alternative B.
	£	£
Stage 1—Gross value of production	3,532,800	6,948,000
Less existing production	325,000	530,000
	3,207,800	6,418,000
Less value of production lost by submergence by Tinaroo Falls Reservoir..	..	257,000
Value of increased production—Stage 1	3,207,800	6,161,000
Stages 1 and 2—Gross value of production	7,289,200	7,289,200
Less existing production	580,000	580,000
	6,709,200	6,709,200
Less value of production lost by submergence by Tinaroo Falls Reservoir ..	257,000	257,000
Value of increased production—Stages 1 and 2	6,452,200	6,452,200

Return on Capital Cost.

Experience throughout the world has shown that in any large irrigation project the direct revenue from water rates and other charges cannot be expected to meet both working expenses and interest and redemption and in most cases can do little more than cover working expenses. In Victoria and New South Wales it has been found necessary for the State to meet the whole of the capital charges involved in the construction of headworks and conveyance of water to the farm boundary, and this practice is becoming general in all countries. Largely because of the high value of tobacco, which will be the principal crop, the Mareeba-Dimbulah Project—at either stage of either alternative scheme—is favourable in that the surplus of direct revenue over working expenses (Table 8) will represent a substantial contribution towards the capital charges.

However, it is on the indirect return represented by the increased value of production that the project should be judged. From the results of irrigation on a large scale in Victoria, it has been estimated that forty (40) per cent. of the increased value of production from an irrigation project accrues to the Commonwealth and State Governments directly in water charges and indirectly in fares, freights, and taxes. Because of the high value of tobacco, which will be the principal crop, the indirect return to Governments is not likely to be less than in Victoria. It may perhaps be greater and a substantial proportion of it will go to the Commonwealth Government.

In Table 11 the total and indirect returns are shown as a percentage of the capital expenditure.

TABLE 11.

ESTIMATED RETURN TO STATE AND COMMONWEALTH GOVERNMENT.

—	Alternative A.		Alternative B.	
	Stage 1.	Stages 1 and 2.	Stage 1.	Stages 1 and 2.
Capital Cost (£)	13,387,850	26,327,400	19,130,050	27,154,400
Increased value of production (£)	3,207,800	6,452,200	6,161,000	6,452,200
Return—				
Total (£)	1,283,100	2,580,900	2,464,400	2,580,900
Direct (as water and drainage charges) (£)	96,500	286,000	250,300	286,000
Indirect (£)	1,186,600	2,294,900	2,214,100	2,294,900
Return as per cent. of capital cost—				
Total	9·6	9·8	12·9	9·5
Indirect	8·9	8·7	11·6	8·4

Comparison of Alternative Schemes.

Whichever dam is built first, production will begin in the fifth year after construction commences, but the rate at which expenditure and production will progress will not be the same for both schemes. Moreover, because of the considerable amount of investigation still required with respect to Alternative B, i.e., Tinaroo Falls Dam first, it has been assumed that commencement of construction may be two years later than in the case of Alternative A, i.e., Nullinga Dam first. The value of production for the completed project will be the same whichever dam is built first, but the total capital cost is slightly greater for Alternative B.

If the project is not carried beyond the first stage then capital expenditure and time of completion will be greater for Alternative B (Tinaroo Falls Dam) than for Alternative A (Nullinga Dam), though this will be offset by a greater production from more farms over a wider area.

The estimated capital expenditure for Stage 1 of Alternative B includes the cost of reconstructing roads and railway on new locations and compensation to owners of land and buildings, but it has not been practicable to assess the cost of disturbance to the community. Stage 1 of Alternative A involves no disturbance of roads, railway or buildings.

The period required for completion of the first stage of either alternative will be governed by the rate at which reticulation channels can be built and farms prepared and brought into production. Experience at Clare indicates that the rate of settlement is not likely to exceed 100 farms per year for several years.

Because of difference in the rate of progress of the two alternatives, a simple comparison of the total capital cost with the ultimate annual value of production does not present a complete picture. In order to assess the relative value of the alternative proposals, it is necessary to examine the estimated total expenditure (capital and working) and return year by year as shown in Tables 12 and 13. The date at which construction of the second stage of either scheme is started will have a major influence upon the results. In computing the figures of Tables 12 and 13 it has been assumed that the second dam will be started in time to permit of continuous progress in the opening of farms for settlement. In the case of Alternative A, construction of Tinaroo Falls Dam will be commenced in the year following completion of Nullinga Dam.

In the case of Alternative B, building of Nullinga Dam need not be started until four years after completion of Tinaroo Falls Dam. However, personnel and plant from Tinaroo could probably be transferred to construction of the Burdekin River Diversion Dam.

If the overlap in construction of the two stages be less than has been assumed or if there is a lapse of time between completion of the first stage and commencement of the second stage, the figures in Tables 12 and 13 will be affected considerably. The upper section of Tables 12 and 13 show the result of carrying out only the first stage of either scheme.

In computing the figures in Table 13 allowance has been made for starting construction of the first dam in Alternative B two years later than in Alternative A. In estimating the increased value of production from Alternative B, allowance has been made for the fact that for two years before production from new irrigated farms commences, there will actually be a loss of production due to resumption and partial submergence of valuable farm land within the storage area of Tinaroo Falls Dam. A similar allowance has not been made in the case of Nullinga Dam because of the low value of grazing land involved.

TABLE 12.

COMPARISON OF TOTAL ANNUAL EXPENDITURE (CAPITAL AND WORKING) ACCUMULATED EXPENDITURE, AND RETURN.—ALTERNATIVE A.

Year.	Annual Expenditure.			Accumulated expenditure.	Return 40 per cent. increased value of production.	Return (1) as per cent. of accumulated expenditure.	Present (2) value of return as per cent. of present value of expenditure.	Remarks.
	Capital expenditure on storage, channels, drainage, and other works.	Working expenses, operation, maintenance and administration.	Capital plus working expenses.					
	£	£	£	£	£			
Stage 1 only—								
1952–53	1,527,220	..	1,527,220	1,527,220	..	..	..	Nullinga Dam commenced Stage 1 Main Channels commenced
1953–54	1,604,980	..	1,604,980	3,132,200	..	..	..	Stage 1 Irrigation and Drainage works commenced
1954–55	1,710,600	..	1,710,600	4,842,800	..	..	..	..
1955–56	1,778,480	..	1,778,480	6,621,280	..	..	..	..
1956–57	1,949,080	25,100	1,974,180	8,595,460	167,200	1·9	1·8	Stage 1 Farm openings commenced
1957–58	1,949,080	35,400	1,984,480	10,579,940	334,000	3·2	4·4	Nullinga Dam completed
1958–59	749,080	44,300	793,380	11,373,320	501,200	4·4	8·0	..
1959–60	758,980	53,300	812,280	12,185,600	668,400	5·5	12·2	..
1960–61	904,770	62,200	966,970	13,152,570	835,400	6·4	16·7	..
1961–62	455,580	74,100	529,680	13,682,250	1,069,200	7·8	22·5	Stage 1 Irrigation and drainage works completed
1962–63	..	83,845	83,845	13,766,095	1,283,120	9·3	29·6	Stage 1 Farm openings completed
Stages 1 and 2—								
1952–53 to 1957–58	As for Stage 1 only.							
1958–59	2,049,080	44,300	2,093,380	12,673,320	501,200	4·0	7·2	Tinaroo Falls Dam commenced
1959–60	2,058,980	53,300	2,112,280	14,785,600	668,400	4·5	10·3	..
1960–61	2,204,770	62,200	2,266,970	17,052,570	809,600	4·7	13·2	..
1961–62	2,752,780	74,100	2,826,880	19,879,450	1,017,600	5·1	16·2	Stage 2 Main Channels commenced
1962–63	2,291,250	83,845	2,375,095	22,254,545	1,205,920	5·4	19·3	Stage 2 Irrigation and drainage works commenced
1963–64	2,279,250	107,445	2,386,695	24,641,240	1,759,520	7·1	23·7	Stage 2 Farm openings commenced; Tinaroo Falls Dam completed
1964–65	853,150	127,195	980,345	25,621,585	2,089,040	8·2	29·5	Stage 2 Main Channels completed
1965–66	621,150	140,005	761,155	26,382,740	2,317,200	8·8	35·6	..
1966–67	697,550	159,725	857,275	27,240,015	2,457,120	9·0	41·5	Stage 2 Irrigation and drainage works completed
1967–68	..	191,610	191,610	27,431,625	2,580,880	9·4	48·1	Stage 2 Farm openings completed

(1) The percentage return shown in this Table has been taken on total expenditure (capital and working), and differs slightly from that shown in Table 11, which has been taken on capital expenditure only.

(2) In calculating present value of return and expenditure, interest has been taken at 4½ per cent.

TABLE 13.

COMPARISON OF TOTAL ANNUAL EXPENDITURE (CAPITAL AND WORKING) ACCUMULATED EXPENDITURE, AND RETURN.—ALTERNATIVE B.

Year.	Annual Expenditure.			Accumulated expenditure.	Return 40 per cent. increased value of production.	Return (1) as per cent. of accumulated expenditure.	Present (2) value of return as per cent. of present value of expenditure.	Remarks.
	Capital expenditure on storage, channels, drainage, and other works.	Working expenses, operation, maintenance and administration.	Capital plus working expenses.					
	£	£	£	£	£			
Stage 1 only—								
1954–55	1,826,220	..	1,826,220	1,826,220	..	..	..	Tinaroo Falls Dam and Stage 1 Main Channels commenced
1955–56	1,870,380	..	1,870,380	3,696,600	..	..	..	Stage 1 Irrigation and Drainage works commenced
1956–57	1,975,100	..	1,975,100	5,671,700	..	..	..	..
1957–58	2,046,380	..	2,046,380	7,718,080	..	..	..	..
1958–59	2,215,880	26,670	2,245,550	9,963,630	124,000	1·2	3·6	Stage 1 Farm openings commenced
1959–60	2,246,880	42,232	2,289,112	12,252,742	299,200	2·4	3·2	Tinaroo Falls Dam completed
1960–61	415,880	50,393	966,273	13,219,015	50,400	3·8	6·3	..
1961–62	478,680	58,679	1,037,359	14,256,374	701,600	4·9	10·1	..
1962–63	1,091,920	68,600	1,160,520	15,416,894	902,400	5·9	14·3	..
1963–64	1,054,780	84,000	1,138,780	16,555,674	1,180,080	7·1	19·3	..
1964–65	800,750	103,023	903,773	17,459,447	1,445,600	8·3	25·0	..
1965–66	821,250	117,512	938,762	18,398,209	1,781,120	9·7	31·5	..
1966–67	863,200	135,925	999,125	19,397,334	2,129,200	11·0	38·4	Stage 1 Main Channels completed
1967–68	422,750	153,225	575,975	19,973,309	2,342,800	11·7	46·1	Stage 1 Irrigation and Drainage works completed
1968–69	..	164,885	164,885	20,138,194	2,464,400	12·2	54·4	Stage 1 Farm openings completed
Stages 1 and 2—								
1954–55 to 1962–63	As for Stage 1 only.							
1963–64	2,220,780	84,000	2,304,780	17,721,674	1,180,080	6·7	18·3	Nullinga Dam commenced
1964–65	2,000,750	103,023	2,103,773	19,825,447	1,445,600	7·3	22·6	..
1965–66	2,021,250	117,512	2,138,762	21,964,209	1,781,120	8·1	27·3	..
1966–67	2,063,200	135,925	2,199,125	24,163,334	2,129,220	8·8	32·3	..
1967–68	1,734,250	153,225	1,887,475	26,050,809	2,342,800	9·0	37·2	Stage 1 Irrigation and Drainage works completed
1968–69	1,946,850	164,885	2,111,735	28,162,544	2,464,400	8·8	41·7	Stage 2 Irrigation and Drainage works commenced; Nullinga Dam completed
1969–70	..	191,210	191,210	28,353,754	2,580,880	9·1	48·0	Stage 2 Irrigation and Drainage works completed; Stage 2 Farms opened

(1) The percentage return shown in this Table has been taken on total expenditure (capital and working) and differs slightly from that shown in Table 11, which has been taken on capital expenditure only.

(2) In calculating present value of return and expenditure, interest has been taken at 4½ per cent.

Ignoring other considerations, a purely financial comparison of the two alternatives at the completion of each stage, as disclosed by the foregoing tables, is given in Table 14.

TABLE 14.

COMPARISON OF CAPITAL AND TOTAL EXPENDITURE AND RETURNS.

Capital expenditure.	Return 40% increased value of production.	Total expenditure, capital and working expenses.	Return as per cent. of total expenditure.	Present value of total expenditure.	Present value of 40% production.	Present value of returns as per cent. present value expenditure.
£	£	£		£	£	
Alternative A—						
Stage 1 only— 13,387,850	1,283,120	13,766,095	9·3	11,411,135	3,377,470	29·6
Stages 1 and 2— 26,327,400	2,580,880	27,431,623	9·4	19,987,203	9,604,583	48·1
Alternative B—						
Stage 1 only— 19,130,050	2,464,400	20,138,194	12·2	14,585,435	7,928,529	54·4
Stages 1 and 2— 27,154,400	2,580,880	28,353,754	9·1	19,109,422	9,176,181	48·0

The table above shows that at both stages, either alternative offers a fair return upon the investment.

In view of the publicity which has been given to the proposed construction of Nullinga Dam, this report has been presented so as to deal fully with the two alternative schemes throughout.

The foregoing comparison of the two schemes shows that Alternative B yields a better all round return than Alternative A, and it also clearly indicates that Stage 1 of Alternative B offers a better investment than either of the complete alternatives, and that the addition of Nullinga Dam adds comparatively little to the increased production from the area.

Modification of Alternative B to Provide an Earlier Supply of Water.

Water can be supplied at an earlier date by modification of Alternative B by—

(*a*) Providing for storage of water during construction of Tinaroo Falls Dam, thereby permitting development of new farms as soon as for Alternative A, i.e. by 1956/57;

(*b*) Construction of a Weir at 167M on the Walsh River and supply by gravity to some 26 existing farms, now mainly dependent upon dry farming, in the Left Bank Walsh Area, earlier than with either Alternative A or B.

The investigation indicates the desirability of deferment indefinitely of Nullinga Dam; construction of Tinaroo Falls Dam; building of a Weir on the Walsh River at 167M; and construction of irrigation works to supply the area that can be served by these storages.

PART II.—WATER RESOURCES.

PHYSIOGRAPHY.

Although the basins of the Walsh and Barron Rivers are contiguous, there is considerable difference in their characteristics. The Walsh River rises on the western slopes of the Dividing Range and receives a relatively low rainfall, while the Barron River rises on the western slopes of the Lamb Range and is fed by the heavy rainfall of the coastal belt.

The Nullinga Dam catchment is bounded on the east and south by the Great Dividing Range, some 40 miles from the coast, varying in elevation from 4,250 feet west of Atherton to 1,700 feet at the dam site, and above this point is 124 square miles in extent. The terrain is mountainous granitic country largely uncleared and with little habitation. The headwaters rise in thick rain forest but on the remainder of the catchment the cover is mainly open forest, the timber being generally of poor quality.

The Barron River catchment above Tinaroo Falls Dam site is bounded by the Nelson and Herberton Ranges to the south and south-west and by the Tinaroo and Lamb Ranges to the east and the Great Divide in the west. It varies in elevation from 4,250 feet to 2,000 feet at the dam site and above this point is 220 square miles in extent. Large areas of the catchment have been cleared and are utilised for dairying or agriculture (maize and peanuts). The remainder of the catchment is mainly rain forest set aside as a State Forest Reserve.

RAINFALL.

The average annual rainfall varies from more than 90 inches along the Lamb Range in the east to less than 26 inches at Dimbulah in the west.

The greater portion of the rainfall is due to summer storms and the distribution of it throughout the year is irregular, as is shown by the following table of mean monthly rainfalls at Mareeba (1895-1950) and Dimbulah (1915-1949 estimated for 1915-1934).

TABLE 15.

MEAN MONTHLY RAINFALLS—MAREEBA AND DIMBULAH.

—	Mareeba.		Dimbulah.	
	Mean rainfall.	Per cent. annual total.	Mean rainfall.	Per cent. annual total.
	Inches.		Inches.	
January	8·67	24·5	5·44	20·9
February	8·67	24·5	7·78	29·9
March	7·36	20·8	4·32	16·6
April	2·39	6·8	1·19	4·6
May	·55	1·5	0·26	1·0
June	·62	1·8	0·64	2·5
July	·33	0·9	0·34	1·3
August	·20	0·6	0·12	0·5
September	·20	0·6	0·25	1·0
October	·57	1·6	0·58	2·2
November	1·46	4·1	2·04	7·8
December	4·31	12·3	3·03	11·7
Total for year	35·33	100·0	26·00	100·0

Apart from the variation during any one year, rainfall varies widely from year to year, as is evident from the rainfall for selected climatic years given below.

TABLE 16.

MAXIMUM AND MINIMUM ANNUAL RAINFALLS—MAREEBA AND DIMBULAH.

Wet years.	Rainfall for year.		
	Mareeba.	Dimbulah	
	Inches.	Inches.	
1910–11 (July to June)	91·49	62·92	Estimated
1933–34	66·48	43·24	
1909–10	51·40	44·46	Estimated
1938–39	50·02	38·72	
Dry Years—			
1925–26	27·41	21·68	Estimated
1941–42	19·45	22·15	
1911–12	16·83	17·65	Estimated
1914–15	12·22	8·48	Estimated

Isohyetal Map.

The distribution of rainfall throughout the region, which is influenced to a great extent by the topography, is shown on the isohyetal map (Fig. 11) based upon rainfall records for the 35 year period 1915 to 1949.

Average annual rainfall on catchment areas obtained from the isohyetal map is given in Table 17.

TABLE 17.

AVERAGE ANNUAL RAINFALL ON CATCHMENT AREAS.

—	Area.	Rainfall.
	Sq. miles.	Inches.
Barron River above Picnic Crossing	88	52·5
Barron River above Tinaroo Falls	220	54·4
Barron River above Mareeba ..	332	51·3
Walsh River above Nullinga ..	124	42·6
Walsh River above Dimbulah ..	398	36·8

STREAM FLOW.

Stream Gauging Records.

Records of actual stream gauging available are as set out in Table 18 below:—

TABLE 18.

STREAM GAUGING RECORDS.

Station.	River mileage. A.M.T.M.	Catchment area.	Period of Record.
Barron River—			
Kuranda (Hydro)	13·3	740	Aug. 1942 to 1950
Kuranda	14·2	736	Aug. 1915 to Nov. 1941 See Table 72
Fairyland	15·4	728	Nov. 1941 to 1950 Several months missing 1946-49
Mareeba	43·6	332	1926 to 1950 See Table 73
Picnic Crossing	78·9	88	1926 to 1950 See Table 74
Walsh River—			
Dimbulah	142·9	398	June 1933 to 1950 See Table 70
Tabacum	158·6	169	Aug. 1948 to 1950 See Table 71

NOTE.—A.M.T.M. denotes "Adopted Middle Thread Mileage."

Although stream gauging has not been carried out at the site of the proposed Tinaroo Dam at 63 miles, the gaugings made at Picnic Crossing upstream and at Mareeba downstream from the site provide a satisfactory record of runoff for the years for which they are available. In the case of reservoirs in this region, sufficiently large to effect a high degree of regulation of runoff, it is usually found that the critical period occurs during droughts such as that of 1914-15. To cover such occurrences it has been necessary to use rainfall data to extend the runoff record to cover a total of 35 years, thereby also eliminating the effect of climatic variations over short periods. The method of extending the records is described in Appendix 1, Hydrology.

EVAPORATION AND SEEPAGE.

Records of evaporation or temperature are not available for any portion of the region covered by the Mareeba-Dimbulah Project. The nearest evaporimeter is at Home Hill, where the mean annual pan evaporation for the 27-year period, 1920 to 1946, is 72·65 inches. Although further to the north, the high elevation at the proposed dam sites will tend to reduce evaporation. Moreover, evaporation from a large water surface such as a reservoir is appreciably less than that from an evaporimeter pan.

With respect to both Tinaroo Falls and Nullinga Dam, the average loss, due to both evaporation and seepage, has been taken as 72 inches per annum, which is regarded as being a safe value.

DISTRIBUTION OF IRRIGATION DEMAND.

The demand for water for irrigation will depend upon seasonal conditions. It will therefore vary from year to year and from month to month in any one year. Since the variation in demand cannot be forecasted, it is necessary in estimating the yield from reservoirs to assume that the average demand will obtain in all years and that the monthly distribution will be as shown in Table 19 below.

TABLE 19.

MONTHLY DISTRIBUTION OF ANNUAL IRRIGATION DEMAND.

Month.	Per cent. of annual demand.	
	Monthly.	Quarterly.
January	5·5	..
February	1·5	..
March..	3·5	10·5
April	7·0	..
May	9·0	..
June	7·0	23·0
July	7·5	..
August	10·0	..
September	12·5	30·0
October	14·5	..
November	12·5	..
December	9·5	36·5
Total	100·0	100·0

COMPENSATION FLOW.

Tinaroo Falls Reservoir.

The existing hydro-electric plant at Barron Falls requires a maximum supply on full load of 212 cusecs, equivalent to 420 acre feet per 24 hours. In estimating the quantity of water which will be available for irrigation it has been assumed that there will be no interference with the hydro-electric plant which will continue to receive the same supply of water at any time as it would if there were no dam.

When the flow at Barron Falls is less than 212 cusecs, water will be released from Tinaroo Falls reservoir to bring the flow at Barron Falls up to 212 cusecs with the proviso that the rate at which water is released from the reservoir shall not exceed the rate of inflow into the reservoir.

The average quantity of water to be released is estimated to be 41,000 acre feet per year.

The Barron River is not known to have ceased flowing and therefore no provision has been made for release of compensative flow to the river itself.

REGULATION OF DRAFT FROM RESERVOIR.

If an irrigation reservoir is operated so as to maintain a constant supply of water in all years, even during the worst drought likely to be experienced, there will be considerable waste of surplus water during wet years, when the irrigation demand is reduced, because a reservoir cannot economically be created of sufficient capacity to store all the inflow. Within practicable limits it is preferable to supply extra water to farms in good or normal years and to restrict the supply when the reservoir has been drawn down to a certain level during dry periods. In this way the greatest overall production can be obtained. Analysis of stream flows indicates that the limits of supply adopted in large southern irrigation schemes will be suitable also in North Queensland.

WATER RIGHTS.

It is proposed to allot to each farm a "Water Right," being a definite quantity of water during a 12-month period, based upon the area of the farm and type of crop for which the soil is considered to be suitable. Charges for water will be based upon the water right.

Operating Rule.

In normal years farmers will be permitted to purchase additional quantities of water up to 30 per cent. in excess of the water right. When the reservoir level has fallen to a predetermined critical level, supplies will be limited to the water right. When the reservoir falls further to another predetermined level, the supply of water will be restricted to 80 per cent. of the water right.

The critical levels referred to have been determined so that, on the basis of inflow to reservoirs experienced in the past, it should not at any time be necessary to restrict supplies to less than 80 per cent. of water rights.

FREQUENCY OF RESTRICTION.

The normal draft has been chosen so that minimum supply is not anticipated to occur for more than two years in sucession.

Reduction of supply is not anticipated to occur for more than three successive years when the combined scheme is fully operating.

Normal supply is expected to be available in 70 per cent. of years.

The reduction in the volume of production during periods of restriction of supply is likely to be offset, at least partially, by higher market prices, which usually prevail during droughts. The absence of excessive rain during years of restricted supply may result in a better quality of tobacco leaf.

DRAFT FROM STORAGE RESERVOIRS.

An hydrological analysis, described in Appendix 1, has been made to determine the quantity of water which can be drawn for irrigation from reservoirs of various storage capacities and also the cost per acre foot of draft.

Nullinga Dam.

The results of the hydrological analysis with respect to Nullinga Dam for the 55-year period 1895-1949 are set out in Table 20 and Fig. 12.

TABLE 20.

NULLINGA DAM—NORMAL DRAFT FOR DIFFERENT STORAGE CAPACITIES.

Elevation of spillway.	Storage capacity.	Normal Annual Draft.			Capital cost (1) of storage capacity per acre foot.	Capital cost of normal annual draft per acre foot.
		Total per annum.	Per acre foot of storage capacity.	Per cent. of average annual river flow.		
R.L.	Acre feet.	Acre feet.	Acre feet.		£	£
1772	120,000	34,000	0·2833	52·0	..	..
1782	160,000	42,000	0·2625	64·0	41·4	157·9
1791	200,000	47,100	0·235	71·7	36·8	156·4
1800	240,000	50,000	0·2083	76·2	34·1	163·6
1807	280,000	50,800	0·1814	77·5	31·5	173·9

(1) The cost of concrete gravity dam has been used in this analysis.

In order to command the area to be supplied, the irrigation outlets will be at R.L. 1710. The storage capacity of 10,000 acre feet in the 60-feet depth below R.L. 1715 is treated as dead storage but is included in the storage capacities given in Table 20.

The normal annual draft and the cost per acre foot of storage capacity and of normal draft are shown graphically in Fig. 20a.

Tinaroo Falls Dam.

The results of a similar hydrological analysis with respect to Tinaroo Falls Dam for the 37-year period 1913-1949 are set out in Table 21 and Fig. 13.

TABLE 21.

TINAROO FALLS DAM—NORMAL DRAFT FOR DIFFERENT STORAGE CAPACITIES.

Elevation of spillway.	Storage capacity.	Normal Annual Draft.			Capital cost of storage capacity per acre foot.	Capital cost of normal annual draft per acre foot.
		Total per annum.	Per acre foot of storage capacity.	Per cent. of average annual river flow.		
R.L.	Acre feet.	Acre feet.	Acre feet.		£	£
2176	200,000	123,000	0·614	46·8	..	..
2188	280,000	152,000	0·543	57·7	26·6	49·0
2193	320,000	165,000	0·516	62·6	24·5	47·4
2198	360,000	177,000	0·491	67·4	22·8	46·4
2204	420,000	194,000	0·462	73·9	..	..
2210	480,000	210,000	0·437	80·5	19·7	45·0
2216	540,000	218,000	0·404	83·0	18·2	45·2

The normal draft given in Table 21 is exclusive of the average annual quantity of 41,000 acre feet to be released for the Barron Falls power plant. However this amount is included in the average annual river flow in determining percentage of such flow represented by normal draft. Dead storage of 11,000 acre feet in the 59 feet of water below the draw off level (R.L. 2119) is included in the storage capacity shown in Table 21.

The normal annual draft and the cost per acre foot of storage capacity and normal draft are shown graphically in Fig. 20b.

BEHAVIOUR OF RESERVOIRS.

Nullinga and Tinaroo Reservoirs can be operated singly as they would be in the first stage of a project or they can be operated in combination. The behaviour, for one particular storage capacity for each reservoir is shown in Fig. 15, and is summarised in Table 22.

TABLE 22.

INDIVIDUAL AND COMBINED RESERVOIR BEHAVIOURS.

—	Nullinga reservoir alone, capacity 240,000 acre feet.	Tinaroo reservoir alone, capacity 320,000 acre feet.	Reservoirs in combination, capacity 560,000 acre feet.
Period examined	1895–1949	1911–1949	1913–1949
Number of water years reservoir filled	10	20	9 (both full)
Number of water years supply not fully met	18	12	9
Number of water years supply reduced to 80% water rights	10	5	4
Greatest number of successive water years of restricted supply	6	3	3

NOTE.—Water years have been taken from 1st April to 30th March.

Nullinga Reservoir operated alone would not have been filled during the 11-year period 1900-1910, and during the 25-year period 1914-1938. Such a high degree of regulation of the runoff is not usual, but there has been a tendency in Australia to make reservoirs too small. Provision of a large storage capacity has therefore been adopted in this report.

Tinaroo Reservoir operated alone would not have filled during the 6-year period 1915-1920.

In the second stage of the project, if both dams were built, irrespective of which is built first, the two reservoirs would be operated in combination. Portion of the area to be served can be supplied from either reservoir by interconnection of portions of the channel systems. The behaviour of the combined reservoirs over the period 1913-1949, when operated to the best advantage is indicated in the last column of Table 22. Of the 9 years in which supplies would not be fully met, 3 would involve only minor reductions of supply.

The longest period during which the combined storage would not be filled would be during the 15 years, 1914-1928. Over the period of 37 years, 1913-1949, combined operation of the reservoirs results in an increase in the average annual yield of 4,000 acre feet per annum and reduces the frequency and extent of reduction in supply. Normal supply would be available in 75 per cent. of years.

DIVERSION OF SURPLUS FLOW FROM BARRON RIVER TO NULLINGA RESERVOIR.

The possibility of diverting surplus flow of the Barron River directly to Nullinga Reservoir by means of a channel has been investigated.

It appears that the yield from Nullinga Reservoir can be appreciably increased by such means but that an equivalent result can be obtained by increasing the storage capacity of Tinaroo Reservoir.

PART III.—STORAGES.

The runoff from the catchment areas of the Walsh and Barron Rivers and the quantity of water which may be drawn annually from reservoirs on those streams has been fully discussed in Part II. (Water Resources) and Appendix I. (Hydrology). This part refers to the construction of dams, the suitability of the sites and economic height and type of dam.

NULLINGA DAM.

Location.

The site of Nullinga Dam is on the Walsh River at A.M.T.M. 161.3 where it breaches a spur of the Great Dividing Range near Mt. Masterton. It is immediately below the confluence with Catherine Creek and is some 18 miles upstream from Dimbulah.

Investigations.

Investigations carried out to date include an aerial survey of the storage area from which a 10-feet contour plan was prepared; a grid level survey covering the immediate vicinity of the site; and a survey of the river for a mile downstream. A programme of diamond and percussion drilling and sinking of shafts to provide information relating to the foundations of the dam is well advanced. Sites for possible borrow pits and quarries are also being explored by drilling and shaft sinking.

A road to provide all weather access to the site is under construction.

Foundations.

A geological report on the site for Nullinga Dam is included as Appendix II. Cross sections of the valley at the site, showing details of drill holes and shafts, will be found on the plan (Fig. 17).

Generally the site is covered by gravel or alluvium reaching a maximum depth of 41 feet on the left bank. The alluvium is underlain by weathered rock which improves in quality with depth. Examination of drill cores and subsurface inspection in shafts indicates that sound rock, which can be adequately sealed by the ordinary process of grouting, is likely to be encountered approximately along the "adopted sound rock line" shown, on the tentatively adopted axis for the dam, (Cross Section $\frac{2100}{3000} - \frac{3900}{3000}$ on plan, Fig. 17). The rock is considered to be adequate as a foundation for either concrete or earth dams. In estimating quantities for concrete dams, it has been assumed that there will be an average depth of 10 feet of rock excavations below the "adopted sound rock line" but that this line will represent the bottom of the cutoff in the core of an earth dam.

Type of Dam.

Preliminary designs for multiple arch and a massive buttress dam indicate that, because of the steel required and need for much skilled labour, these types do not offer a reduction in cost compared with that of a gravity dam.

Irrespective of the type adopted for the main dam, a low earthen dam will be required on an adjacent saddle, as shown in Fig. 18.

Concrete Gravity Dam.

The estimated cost and storage capacity of concrete gravity dams of various heights is shown in Table 23.

TABLE 23.

CAPACITY AND ESTIMATED CAPITAL COST FOR VARIOUS HEIGHTS OF CONCRETE GRAVITY DAM AT NULLINGA.

Spillway crest.	Approximate height above stream bed.	Storage capacity.	Capital cost.	
			Total.	Per acre foot of storage capacity.
R.L.	Feet.	Acre feet.	£	£
1782	130	160,000	6,629,000	41·4
1791	139	200,000	7,363,000	36·8
1800	148	240,000	8,178,000	34·1
1807	155	280,000	8,827,000	31·5

The values in Table 23 are shown graphically in Fig. 20a, from which it can be seen that, although the cost per acre foot of storage falls slightly as the storage capacity increases, the rate of increase of normal annual draft falls off rapidly and its cost per acre foot rises appreciably beyond a storage capacity of 240,000 acre feet.

The overall economic result for a first stage of the project, supplied from storages of various capacities at Nullinga, including the cost of both irrigation works and a concrete dam, is shown graphically in Fig. 21a. The rate of increase of net annual return lessens and the percentage return drops considerably beyond a storage capacity of 240,000 acre feet.

A storage of 240,000 acre feet and a normal annual draft of 50,000 acre feet has therefore been adopted as the economic limit of development from a dam at Nullinga.

Earth Dam.

The diversion of large flood flows in the river during construction of a concrete dam is a comparatively simple matter, but in the case of an earth dam in a region of tropical storms, it becomes a more difficult problem and involves the building of a large concrete-lined tunnel or a large concrete conduit beneath the dam.

The adoption of an earth dam greatly reduces the quantity of cement required and a preliminary design for such a dam, embodying a side channel spillway discharging through the diversion tunnel, is shown in Fig. 18.

The estimated cost of an earth dam to store 240,000 acre feet (full supply level, R.L. 1800) is £7,166,000. This figure, being less than the cost of a concrete dam, was used in subsequent economic analyses.

The determination of the proposed spillway capacity of 50,000 cusecs is dealt with in Appendix I. (Hydrology).

Submerged Area.

At R.L. 1800 an area of 5,080 acres will be submerged. The land to be submerged is uninhabited and is for the most part held as grazing holdings except for some 10 Mining Homestead Leases approximately two miles above the dam site. The whole area may be regarded as low-grade grazing land. Resumption costs, which will not be high, have been allowed for in the estimated cost of the dam.

WEIR AT 167M ON WALSH RIVER.

A suitable site exists for construction of a weir at 167M on the Walsh River some 6 miles above Nullinga Dam site.

Investigations of the site, including a grid survey and foundation investigations, indicate that a weir some 30 feet high with crest level at R.L. 1790 would have a capacity of 840 acre feet and could be constructed at an estimated cost of £150,000.

The bed level of the river at this point is R.L. 1759 and would permit the diversion by gravity from the weir to the South Walsh Main Channel.

If Stage 1 only of Alternative B is adopted, this weir together with the South Walsh Main Channel and a connecting channel from the weir to this channel could be constructed simultaneously with Tinaroo Falls Dam. This arrangement would permit supply to some 26 existing tobacco farms in the Left Bank Walsh area now dependent on dry farming, and urgently in need of irrigation, some 3 years ahead of supply from either Nullinga or Tinaroo Falls Dam.

When supply is available from Tinaroo Falls Dam the weir could continue to be used for the following purposes:—

(*a*) Diversion of unregulated flow from the Walsh River to the Left Bank Walsh Area.

(*b*) Supply to a small area of tobacco lands between the weir and the Nullinga Dam site.

(*c*) As a balancing pond to store overflow water from the Walsh Bluff Main Channel for use in the Left Bank Walsh Area.

TINAROO FALLS DAM.

Location.

The site selected is that known as Bond's Site on the Barron River in Tinaroo Gorge at A.M.T.M. 63 miles. It is near the head of the series of rapids known as Tinaroo Falls.

Investigations.

Aerial surveys have been made of the area to be submerged, and ground control surveys together with plotting of contours will be completed within a few months. A contour survey for a dam of moderate height was made in 1939 and, pending completion of the ground control surveys, the area submerged and the storage capacity at various levels have been determined approximately from military contour maps.

A grid survey of the site has also been commenced.

Foundations.

Only surface inspection of the site has as yet been made, but drilling and shaft sinking are being commenced.

Apparently sound granite is exposed across the bed of the river. The right bank rises steeply and indicates the presence of rock at moderate depth. The left bank rises more gradually with less outcropping of granite on the surface and a sound rock on this bank may be fairly deep. Generally the site appears to be attractive for the building of a conrete dam.

Gravity Dam.

The preliminary design for a gravity dam, shown in Fig. 19, is based upon a single cross-section and further investigation may result in some modification of the location of the axis of the dam. Quantities have been estimated with respect to the assumed excavation line shown on the plan. The location of an auxiliary earth bank on a saddle is also shown.

The capacity of the central overfall spillway is dealt with in Appendix I. (Hydrology).

The estimated cost and storage capacity of concrete gravity dams of various heights is shown in Table 24.

TABLE 24.

CAPACITY AND ESTIMATED CAPITAL COST FOR VARIOUS HEIGHTS OF CONCRETE GRAVITY DAM AT TINAROO FALLS.

Spillway crest.	Approximate height above stream bed.	Storage capacity.	Capital cost.	
			Total.	Per acre foot of storage capacity.
R.L.	Feet.	Acre feet.	£	£
2188	128	280,000	7,457,000	26·6
2193	133	320,000	7,830,000	24·4
2198	138	360,000	8,211,000	22·8
2210	150	480,000	9,450,000	19·7
2216	156	540,000	9,845,000	18·4

The values in Table 24 are shown graphically in Fig. 20b.

The overall economic result for a first stage of the project, supplied from storages of various capacities at Tinaroo Falls, including the costs of both irrigation works and a concrete dam, is shown graphically in Fig. 21b.

Although the cost per acre foot of storage decreases with increase of storage capacity, beyond 320,000 acre feet, the net annual return does not increase much beyond that capacity and the percentage return falls.

A storage of 320,000 acre feet and a normal annual draft for irrigation of 165,000 acre feet have therefore been adopted as the economic limit of development from a dam at Tinaroo Falls. It is possible that some modification of these values may be necessary after completion of the contour plan of the submerged area.

Submerged Area.

The construction of Tinaroo Falls Dam will cause the submergence of a considerable area of agricultural land and forest reserve, the small township of Kulara, and several miles of railway and roads.

The total area of land actually submerged will be approximately 10,000 acres, but resumption of some 15,000 acres, including 1,700 acres of forest reserve, has been allowed for.

The types and present utilisation of the land to be resumed are:—

	Acres.
Forest	2,135
Scrub	2,861
Grazing	3,024
Dairying	3,760
Agriculture	1,524
State forest	1,700
	15,004

A timber mill near the lower end of Robson's Creek will also be submerged.

About 5½ miles of the Tolga-Millaa Millaa Railway will have to be reconstructed on a new location, including a new crossing of the Barron.

Reconstruction of 14 miles of roads, including 9 miles of secondary roads, will be necessary.

Allowance has been made in the estimate of cost for reconstruction of roads and railways and resumption of land and buildings.

NULLINGA AND TINAROO DAMS.

For the complete project, involving two stages with both Nullinga and Tinaroo Dams in operation, the overall economic result for a storage capacity of 240,000 acre feet at Nullinga Dam and various total storage capacities, including the costs of both irrigation works and dams, is shown graphically in Fig. 21c. Beyond a storage capacity of 560,000 acre feet (Nullinga, 240,000; Tinaroo Falls, 320,000), the capital cost increases greatly whereas the annual return increases hardly at all and the percentage return falls considerably. These figures therefore confirm the economic limit of storage capacity found in the case of one dam supplying a single stage.

PART IV.—SOILS, LAND USE AND WATER REQUIREMENTS.

SOILS.

Information Available.

Information on the soils of the area has been derived from a report and map prepared by officers of the Queensland Bureau of Investigation following a survey of the area in October and November, 1950.

The survey was of a reconnaissance nature only, but the present and past development of the area provides satisfactory experience of most of the soils of the area, so the survey has been considered sufficiently accurate to be used as a basis for preparation of the proposed plan of development.

Some 25 general types have been delineated and potential land use for these soils suggested by the Bureau Officers.

The report and soil map prepared by the Bureau of Investigation Officers are attached (see Appendix III. and Fig. 23).

Types and Areas.

In order to facilitate the investigation of proposed development of the area, the general types have been combined into four major groups according to potential land use, details and areas of which are set out in Table 25 below, and indicated on the plans (Figs. 2 and 3). The areas shown are the gross areas mapped, and apply to both alternative schemes, and include some areas above the level and beyond the limits of the proposed channel system.

TABLE 25.

MAJOR SOILS GROUPS—POTENTIAL LAND USE AND GROSS AREAS MAPPED.

Group.	General characteristics.	Potential land use.	Gross area.
			Acres.
A	Fine sands and sandy loams of schist origin. Fine sands and sandy loams of levees or flats adjoining streams	Tobacco ..	65,250
B	Podsolised sandy soils with clay at shallow depths ; also shallow phases of schistose sandy loams	50% Tobacco .. 50% Pasture ..	34,100 ..
C	Mainly red loams of basaltic origin	Agriculture excluding tobacco	38,700
D	Chiefly solonised clays and podsolised alluvials with heavy clay at shallow depth	Pastures ..	51,170
	Total	..	189,220

Topography.

The topography of the lands proposed for development varies from easy slopes to relatively steep foothill country with grades up to 4 feet per chain.

Although the latter areas are not ideal for irrigation and soils are such as to require close attention to soil conservation methods, the present use of similar lands indicates the practicability of utilisation.

Careful layout of plantings readily possible with row crops such as tobacco, concrete-lined head ditches or pipe lines and the retention of grassed tail drain areas will minimise difficulties of steep grades.

The relatively steep grades will generally be advantageous for channel and drainage systems, as they will enable smaller cross sections to be used than is the case with flatter grades.

LAND USE.

Existing Land Use.

The production of tobacco under irrigation now forms the most important land use practice in the area. This method of production has developed as a result of failures under dry farming conditions in the early years of development of the industry, which commenced mainly in the early 1930's and following which many farms were abandoned due largely to inability to obtain water supply for irrigation.

Some dry farming continues chiefly in the Paddy's Green and Dimbulah localities. Best results, both dry and irrigated, are obtained on the lighter sandy loams and alluvia. The main crops produced in conjunction with tobacco are peanuts, cowpeas, and maize.

On the basaltic soils between Mareeba and Tolga maize and peanuts are the chief crops, with some tobacco, which is not, however, regarded as a suitable crop for these soils.

The plan (Fig. 8), shows the extent of existing and abandoned development.

Proposed Land Use.

The object of the Mareeba-Dimbulah project is primarily to enable development of tobacco production under irrigation. However, the water available from the proposed reservoirs will be sufficient to water all available tobacco soils, practically all mixed agricultural soils, and a substantial portion of the pasture soils. This arrangement will facilitate development by providing reasonably compact areas, as the tobacco soils occur in relatively dispersed areas, between which mixed agriculture and pasture soils occur.

In planning the water utilisation for the project, provision has been made for production of vegetables, peanuts, and other cash crops, in conjunction with tobacco, during that part of the year when tobacco is not being grown.

Farm Sizes and Water Allocations.

For the various types of production and for both alternatives, Table 26 sets out the values adopted for average areas of farms, water right allocation, and allowance for water sales, the latter in all cases being limited to 30 per cent. of water rights.

TABLE 26.

AVERAGE FARM SIZES AND WATER ALLOCATION.

Stage.	Farm type.	Alternative A.					Alternative B.				
		Average area.	Water Right.		Water sales.	Total water available.	Average area.	Water Right.		Water sales.	Total water available.
			Allocation.	Volume.				Allocation.	Volume.		
		acres.	acre feet per acre.	acre feet.	acre feet.	acre feet.	acres.	acre feet per acre.	acre feet.	acre feet.	acre feet.
1 ..	Tobacco	50	½	25	7·5	32·5	50	¾	37·5	11·2	48·7
	Mixed agriculture ..	..	..	..	..	..	80	1	80	24	104
2 ..	Tobacco	50	¾	37·5	11·2	48·7	50	¾	37·5	11·2	48·7
	Mixed agriculture ..	80	1	80	24	104	80	1	80	24	104
	Pasture	200	1	200	60	260	200	1	200	60	260

The lower allocation of water rights and restriction of development to tobacco lands for Stage 1, Alternative A, has been adopted to obtain the maximum possible area of development and the most favourable returns from capital invested in this stage.

WATER REQUIREMENTS.

Annual water requirements in inches per acre adopted for the various types of production considered for the project are as follows:—

	Inches.
Tobacco	24
Vegetables	24
Mixed agriculture	31
Pastures	31

Monthly Demand.

The average monthly percentage of annual water requirements adopted in investigation of the project are set out in Part II. (Water Resources) Table 19.

Distribution Efficiency.

In determining channel capacities and requirements of water from storages a value of 50 per cent. has been adopted for efficiency of water distribution from storages to farms.

PART V.—PROPOSED DEVELOPMENT.

General Layout.

Tentative locations for the main channels and reticulation systems from both reservoirs have been fixed on the topographical information available.

This shows that water can be diverted from the Barron River on to lands in the Walsh and Upper Mitchell catchments. The combination of the two systems will enable greater development of these areas than would be possible by supply from Nullinga Dam only.

Areas Commanded.

The gross areas of the various soil groups suitable for development and commanded by the individual and combined systems together with certain areas of potentially highly productive soils considered suitably located for supply by pumping from the channel systems have been determined from the general layout plan.

The estimated areas available for farms have generally been taken as 80 per cent. of the gross areas, leaving 20 per cent. allowed for townships, road, channel, drainage, and railway reserves and for areas of unsuitable topography.

Details of gross areas of suitable soils and farm areas commandable by gravity and pumping by channel systems supplied from Nullinga or Tinaroo Falls dams individually and from systems capable of supply by either storage are set out in Table 27. The areas shown are similar for both Alternatives A and B.

TABLE 27.

AREAS COMMANDABLE BY GRAVITY OR PUMPING.

Land Use.	Alternative A.					Alternative B.			
	Gross Areas.				Farm Areas.	Gross Areas.			Farm areas.
	Supply from Nullinga Dam only.	Supply from Nullinga Dam or Tinaroo Falls Dam.	Supply from Tinaroo Falls Dam only.	Total.		Supply from Nullinga Dam or Tinaroo Falls Dam.	Supply from Tinaroo Falls Dam only.	Total.	
	acres.	acres.	acres.	acres.	acres.	acres.	acres.	acres.	acres.
Tobacco ..	15,800	47,300	13,500	76,600	61,300	63,100	13,500	76,600	61,300
Mixed agriculture..	3,300	7,200	26,500	37,000	29,600	10,500	26,500	37,000	29,600
Pasture ..	7,900	47,500	4,900	60,300	48,300	55,400	4,900	60,300	48,300
	27,000	102,000	44,900	173,900	139,200	129,000	44,900	173,900	139,200

Complete development of the commandable area under the conditions of water allocation adopted would require approximately 50 per cent. more water than is available from the proposed storages, so that a selection of the area to be developed has been made.

Selection of Area to be Developed.

In selecting the area to be developed priority has generally been fixed as follows:—

(1.) Tobacco soils (including pumped areas);

(2.) Mixed agriculture soils;

(3.) Pasture soils.

To assist in the planning and selection of areas for development, the area within the project has been subdivided into 23 sections, as shown in the plans (Figs. 4 and 5), which are generally limited by natural features and served by self contained sections of the channel systems.

Details of the areas selected for the proposed two stages of development showing gross areas commanded, farm areas reticulated, numbers and types of farms, for Stages 1 and 2, are set out in Table 28 for Alternative A and Table 29 for Alternative B.

STAGE DEVELOPMENT.

As the project involves the construction of two dams each with its associated channel systems, the development is proposed to be divided into two stages, which for the two alternative proposals are as follows:—

Alternative A.

Stage 1.

Construction of Nullinga Dam.

Construction of main channel systems—

South Walsh Main,

North Walsh Main to Five Mile Creek,

Southedge Main to Boyle Creek,

Part Biboohra Main,

Part Four Mile Creek Lateral.

Construction of reticulation systems to serve tobacco lands commandable from these main channels.

Construction of drainage works to serve the tobacco lands reticulated.

This stage would command a total area of 129,300 acres, in which 38,400 acres would be developed, and of which 12,300 acres would be irrigated annually. Water right allocation would be ½ acre foot per acre of irrigable farm areas.

Stage 2.

Construction of Tinaroo Falls Dam.

Construction of the balance of the irrigation works, involving connection to and extension of Stage 1 main channel systems and reticulation systems, and construction of the irrigation works served by Tinaroo Falls Dam only.

Construction of drainage works for the balance of the area developed.

In this stage water right allocation on Stage 1 farms would be increased to ¾ acre foot per acre of irrigable farm area, and the area commanded would be increased by 87,200 acres to 216,500 acres. Additional farms developed would include 412 tobacco, 333 mixed agriculture, and 59 pasture farms, comprising some 59,000 acres of which 29,000 acres would be irrigated annually.

Sixty-eight mixed agriculture and all the pasture farms would be developed within the area commanded by Stage 1 channel system.

Alternative B.

Stage 1.

Construction of Tinaroo Falls Dam.

Construction of all main channel systems with exception of the first 2½ miles of North Walsh main.

In order to serve the Left Bank Walsh area from this stage the Walsh Bluff Main channel would be necessary to carry water from the West Barron Main via Walsh Bluff and a syphon at Nullinga Dam site to the South Walsh Main (see Fig. 2).

Construction of reticulation systems from main channel systems to serve—

1,180 tobacco farms;

240 mixed agriculture farms,

comprising an area of 78,200 acres of which 37,900 acres would be irrigated annually, of a total area commanded of some 216,500 acres.

Construction of drainage works to serve farm areas developed.

Water right allocations for this stage would be ¾ acre foot per acre for tobacco farms and 1 acre foot per acre for mixed agriculture farms.

Stage 2.

Construction of Nullinga Dam.

Construction of North Walsh Main Channel from Nullinga Dam to junction with Walsh Bluff Main.

Construction of reticulation systems to serve a further 93 mixed agriculture and the 59 pasture farms which would be developed within the area commanded by the Stage 1 main channel system.

The additional area of farms served in this stage would be 19,200 acres of which some 9,600 acres would be irrigated annually. No additional land would be commanded by the main channel system.

Details of the areas selected for development, including gross areas, farm areas, and numbers and types of farms for Stages 1 and 2 development for Alternative A are set out in Table 28 and for Alternative B in Table 29.

TABLE 28.

LOCATION, EXTENT AND NATURE OF DEVELOPMENT.

ALTERNATIVE A.

Location.	Gross areas of soils groups commanded.					Farm areas and percentage of gross areas.								Numbers of farms.			
						Tobacco.		Mixed agriculture.		Pasture.		Total.					
	Group A and 50% Group B.	Group C.	Group D and 50% Group B.	Unsuitable or unmapped.	Total.	Area.	Per cent. of gross area.	Area.	Per cent. of gross area.	Area.	Per cent. of gross area.	Area.	Per cent. of gross area.	Tobacco.	Mixed agriculture.	Pasture.	Total.
	acres.	acres.	acres.	acres.	acres.	acres.		acres.		acres.		acres.					
Stage 1.																	
Left Bank Walsh	14,000	3,300	5,500	7,000	29,800	11,200	79·8	..	..	..	..	11,200	37	224	..	..	224
Right Bank Walsh	23,200	1,600	15,800	11,700	52,300	15,700	67·9	..	..	..	..	15,700	30	314	..	..	314
Paddy's Green commanded, South Biboohra, Southedge and part North Biboohra	15,000	1,200	22,600	8,400	47,200	11,500	76·5	..	..	..	..	11,500	24	230	..	..	230
Total Stage 1	52,200	6,100	43,900	27,100	129,300	38,400	73·5	..	..	..	..	38,400	30	768	..	..	768
Stages 1 and 2.																	
Left Bank Walsh	14,000	3,300	5,500	7,000	29,800	11,200	79·8	2,640	80·3	..	..	13,840	46	224	33	..	257
Right Bank Walsh	23,200	1,600	15,800	11,700	52,300	18,550	80·1	1,280	81·3	7,800	49·5	27,630	53	371	16	39	426
Paddy's Green commanded, South and North Biboohra, Four Mile Creek, Southedge	15,200	2,500	23,200	8,400	49,300	12,100	79·9	1,520	60·5	2,400	10·3	16,020	33	242	19	12	273
Paddy's Green Pumped	6,900	..	1,500	2,600	11,000	5,500	80·0	..	..	..	..	5,500	50	110	..	..	110
Rocky Creek, Granite Creek, Atherton Creek, Mareeba, Springmount, Pumped	6,400	18,000	4,200	11,500	40,100	5,200	80·6	14,400	80·2	1,600	13·9	21,200	53	104	180	8	292
Nardello's Lagoon Pumped	100	2,400	..	1,700	3,200	100	103·1	1,920	81·0	..	..	2,020	63	2	24	..	26
Ada Creek, Emerald Creek, Clohesy ..	7,900	6,200	1,500	15,300	30,900	6,350	80·1	4,880	79·3	..	..	11,230	36	127	61	..	188
Total Stages 1 and 2	73,700	34,000	51,700	58,200	217,600	59,000	80·1	26,640	78·6	11,800	22·8	97,440	45	1,180	333	59	1,572

TABLE 29.

LOCATION, EXTENT AND NATURE OF DEVELOPMENT.

ALTERNATIVE B.

Location.	Gross areas of soils groups commanded.					Farm areas and percentage of gross areas.								Numbers of farms.			
	Group A and 50% Group B.	Group C.	Group D and 50% Group B.	Unsuitable or unmapped.	Total.	Tobacco. Area.	Tobacco. Per cent. of gross area.	Mixed agriculture. Area.	Mixed agriculture. Per cent. of gross area.	Pasture. Area.	Pasture. Per cent. of gross area.	Total. Area.	Total. Per cent. of gross area.	Tobacco.	Mixed agriculture.	Pasture.	Total.
	acres.	acres.	acres.	acres.	acres.	acres.		acres.		acres.		acres.					
Stage 1.																	
Rocky Creek, Granite Creek, Atherton Creek, Mareeba, Springmount ..	6,400	18,000	4,200	11,500	40,100	5,200	80·6	10,160	56·6	..	..	15,360	38	104	127	..	231
Left Bank Walsh	14,000	3,300	5,500	7,000	29,800	11,200	79·8	2,640	80·3	..	..	13,840	46	224	33	..	257
Right Bank Walsh	23,200	1,600	15,800	11,700	52,300	18,550	80·1	..	..	..	..	18,550	36	371	..	..	371
Paddy's Green commanded, North and South Biboohra, Southedge, Four Mile Creek	15,200	2,500	23,200	8,400	49,300	12,100	79·9	1,520	60·5	..	..	13,120	28	242	19	..	261
Paddy's Green Pumped	6,900	..	1,500	2,600	11,000	5,500	80·0	..	..	..	..	5,500	50	110	..	..	110
Ada Creek, Emerald Creek, Clohesy ..	7,900	6,200	1,500	15,300	30,900	6,350	80·2	2,960	48·1	..	..	9,310	30	127	37	..	164
Nardello's Lagoon	100	2,400	..	1,700	3,200	100	100·0	1,920	81·0	..	..	2,020	13	2	24	..	26
Total Stage 1	73,700	34,000	51,700	58,200	217,600	59,000	80·1	19,200	56·7	..	..	78,200	36	1,180	240	..	1,420
Stages 1 and 2.																	
Rocky Creek, Granite Creek, Atherton Creek, Mareeba, Springmount ..	6,400	18,000	4,200	11,500	40,100	5,200	80·6	14,400	80·2	1,600	37·9	21,200	53	104	80	8	292
Left Bank Walsh	14,000	3,300	5,500	7,000	29,800	11,200	79·8	2,640	80·3	..	..	13,840	46	224	33	..	257
Right Bank Walsh	23,200	1,600	15,800	11,700	52,300	18,550	80·1	1,280	81·3	7,800	49·5	27,630	53	371	16	39	426
Paddy's Green commanded, North and South Biboohra, Southedge, Four Mile Creek	15,200	2,500	23,200	8,400	49,300	12,100	79·9	1,520	60·5	2,400	10·3	16,020	33	242	19	12	273
Paddy's Green Pumped	6,900	..	1,500	2,600	11,000	5,500	80·0	..	..	..	..	5,500	50	110	..	..	110
Ada Creek, Emerald Creek, Clohesy ..	7,900	6,200	1,500	15,300	30,900	6,350	80·2	4,880	79·3	..	..	11,230	36	127	61	..	188
Nardello's Lagoon	100	2,400	..	1,700	3,200	100	100·0	1,920	81·0	..	..	2,020	63	2	24	..	26
Total Stages 1 and 2	73,700	34,000	51,700	58,200	217,600	59,000	80·1	26,640	78·6	11,800	22·8	97,440	45	1,180	333	59	1,572

AREAS SERVED BY PUMPING.

Included in the lands selected for development are two categories situated above channel level in which supply will be—

(*a*) By private pumping unit; or

(*b*) By central pumping plants delivering from the main channel system to high level channel reticulation systems.

The areas to be supplied by private pumping comprise some 1,750 acres situated adjacent to the South Walsh Main and North Walsh Main Channels.

The areas to be supplied from central pumping stations are—

Paddy's Green (pumped);

Nardello's Lagoon.

For Alternative A, the Springmount area would also be served by pumping, but in Alternative B this area would be served by gravity.

Paddy's Green Area.

This area consists of high-quality tobacco soil already supporting several farms producing tobacco under dry farming conditions, the highest portion of which rises to some 400 feet (R.L. 2050) above channel level (R.L. 1650).

The tentative arrangement of stations is as follows:—

Main Channel to R.L. 1750—Two stations.

Main Channel to R.L. 1850—One station.

Channel at R.L. 1850 to R.L. 1950—One relift station.

Springmount Area.

This area comprises 800 acres of tobacco soils situated at a level between the North Walsh Main Channel (R.L. 1700) and R.L. 1830.

In Alternative A it is proposed to supply the area through a single pumping station delivering from the main channel to a high level channel system.

For Alternative B the method of supply to this area would be by gravity from a branch channel from the Walsh Bluff Main Channel.

Nardello's Lagoon Area.

This area comprises 2,020 acres of valuable mixed agricultural land and is situated between channel level (R.L. 1870) and a level of R.L. 1930.

It is proposed to supply the area through a single pumping station delivering from the main channel to a high-level channel system.

It is proposed to develop all the areas to be supplied by pumping in the second stage of development for Alternative A and in the first stage for Alternative B, and the extent of the area to be developed and approximate static pumping heads for the various sections are set out in Table 30 for the two alternative schemes.

TABLE 30.

AREAS TO BE DEVELOPED BY CENTRAL PUMPING STATIONS.

Area.	Alternative A.		Alternative B.	
	Farm areas.	Static head.	Farm areas.	Static head.
	Acres.	Feet.	Acres.	Feet.
Paddy's Green to R.L. 1750	2,700	100	..	..
Paddy's Green R.L. 1750 to R.L. 1850	1,800	200	4,500	200
Paddy's Green R.L. 1850 to R.L. 1950	1,000	300	1,000	300
Springmount	800	130	..	..
Nardello's Lagoon	2,020	60	2,020	60

LAND RESUMPTION AND RESUBDIVISION.

Design of Area.

The detailed design of channel, drain, and road locations will be based on detailed topographical and soil surveys. It is proposed to design a complete resubdivision of the project area to combine efficient and economical arrangement of farm irrigation and drainage works and farm working, with economical arrangement of irrigation and drainage reticulation systems.

No deviations of existing main roads or railway lines are contemplated, but subsidiary roads will in most cases be relocated to fit in with farm and irrigation layouts.

Land Resumptions and Retention Areas.

The resubdivision will involve almost complete resumption of lands within the project area, and such resumptions would be carried out under the provisions of the Irrigation Acts.

However, in the case of holdings on which agricultural production is at present practised, it is proposed that under the provisions of section 15 (5) of the Irrigation Acts, landholders, on application to the Minister for Lands and Irrigation, may be permitted to retain unresumed, sufficient land to enable them to continue agricultural production under irrigation.

Unresumed portions would as far as possible be such as to coincide with the designed subdivision and include as far as possible existing improvements (cultivated land, buildings, &c.).

Provision has been made in the estimates of capital cost (see Part IX.) for land resumptions.

From the information obtained by the Bureau of Investigation, see plan (Fig. 8), the numbers of allotments on which cultivation is now in existence have been determined, for the two stages of development, the various areas of development, and the various soil or land use groups.

These allotments have been assumed to represent the maximum number of retention areas likely to be required. In some cases more than one allotment may at present be held by the one landholder, and in such cases only one retention area will be allowed. The number of retention areas given below may therefore be slightly larger than will actually be the case.

This information, together with the total numbers of farms in each area and the new farms available for settlement is given in Table 31 for the two alternative schemes.

TABLE 31.

TOTAL NUMBERS OF FARMS, RETENTION AREAS, AND FARMS AVAILABLE FOR SETTLEMENT.

ALTERNATIVE A.

Area.	Total farms.			Retention areas.		Farms available for settlement.		
	Tobacco.	Mixed agri-culture.	Pasture.	Tobacco.	Mixed agri-culture.	Tobacco.	Mixed agri-culture.	Pasture.
Stage 1—								
Left Bank Walsh ..	224	..	..	68	..	156	..	..
Part Right Bank Walsh	314	..	..	18	..	296	..	..
Paddy's Green, South Biboohra	159	..	..	14	..	145	..	..
Southedge, part North Biboohra	71	..	..	6	..	65	..	..
Total Stage 1 ..	768	..	..	106	..	662	..	..
Stage 2—								
Left Bank Walsh ..	..	33	..	..	..	..	33	..
Right Bank Walsh to 5 Mile Creek ..	..	6	39	..	..	..	6	39
Right Bank Walsh beyond 5 Mile Creek	57	10	..	5	..	52	10	..
Paddy's Green, South and North Biboohra, 4 Mile Creek and Southedge	12	19	12	2	..	10	19	12
Paddy's Green Pumped	110	..	..	1	..	109	..	..
Rocky Creek, Granite Creek, Atherton Creek, Mareeba, Springmount Pumped	104	180	8	17	21	87	159	8
Nardello's Lagoon, Pumped	2	24	..	..	5	2	19	..
Ada Creek	5	37	..	2	..	3	37	..
Emerald Creek ..	80	24	..	44	..	36	24	..
Clohesy	42	..	..	7	..	35	..	..
Total Stage 2 ..	412	333	59	78	26	334	307	59
Total Stages 1 and 2	1,180	333	59	184	26	996	307	59

ALTERNATIVE B.

Area.	Total farms.			Retention areas.		Farms available for settlement.		
	Tobacco.	Mixed agri-culture.	Pasture.	Tobacco.	Mixed agri-culture.	Tobacco.	Mixed agri-culture.	Pasture.
Stage 1—								
Rocky Creek, part Granite Creek, part Atherton Creek, Mareeba, Springmount	104	127	..	17	14	87	113	..
Left Bank Walsh ..	224	33	..	68	..	156	33	..
Part Right Bank Walsh	371	..	..	23	..	348	..	..
Part Paddy's Green commanded, South Biboohra, North Biboohra, Southedge, Four Mile Creek	242	19	..	22	..	220	19	..
Paddy's Green, Pumped	110	..	..	1	..	109	..	..
Ada Creek, part Emerald Creek, Clohesy	127	37	..	53	..	74	37	..
Nardello's Lagoon, Pumped	2	24	..	..	5	2	19	..
Total Stage 1 ..	1,180	240	..	184	19	996	221	..
Stage 2—								
Balance Granite Creek, Balance Atherton Creek	..	53	8	..	7	..	46	8
Balance Right Bank Walsh	..	16	39	..	..	..	16	39
Balance Paddy's Green commanded ..	..	..	12	..	..	..	..	12
Balance Emerald Creek	..	24	..	..	..	..	24	..
Total Stage 2 ..	..	93	59	..	7	..	86	59
Total Stages 1 and 2	1,180	333	59	184	26	996	307	59

LAND TENURE.

Present Tenure.

At present the approximate land tenure in the project area is as set out in Table 32 for the two alternative schemes.

TABLE 32.

EXISTING LAND TENURES ON AREAS TO BE DEVELOPED.

Stage.	Tenure.	Alternative A.		Alternative B.	
		Area.	Per cent. of total area.	Area.	Per cent. of total area.
		acres.		acres.	
1 ..	Reserves	5,000	5·4	4,000	3·3
	Special leases	1,000	1·1	1,000	0·8
	Occupation License	13,000	13·9	12,000	10·0
	Mining homestead leases	3,000	3·2	2,000	1·7
	Agricultural farm	..	..	4,000	3·3
	Perpetual lease selection	18,000	19·4	26,000	21·7
	Holdings	18,000	19·4	23,000	19·2
	Vacant	19,000	20·4	19,000	15·8
	Freehold	16,000	17·2	29,000	24·2
		93,000	100·0	120,000	100·0
1 and 2	Reserves	5,000	3·4	5,000	3·4
	Special leases	1,000	0·7	1,000	0·7
	Occupation license	15,000	10·1	15,000	10·1
	Mining homestead lease	3,000	2·2	3,000	2·2
	Agricultural farm	5,000	3·4	5,000	3·4
	Perpetual lease selection	32,000	21·6	32,000	21·6
	Holdings	28,000	18·9	28,000	18·9
	Vacant	23,000	15·5	23,000	15·5
	Freehold	36,000	24·2	36,000	24·2
		148,000	100·0	148,000	100·0

The areas of land tenure indicated in the above table are those considered necessary for resumption and resubdivision for the area to be developed as farms in each stage of the two alternative schemes. Where portions are to be partly developed resumption of complete portions has been allowed for. The areas therefore considerably exceed the area to be developed as farms.

Future Tenure.

It is proposed that all new farms will be opened on perpetual lease tenure under the Irrigation Acts. To avoid difficulties of determining compensation for change of tenure it is expected that all retention areas will retain their present tenure.

Rentals for new farms to be opened as perpetual lease selections are dealt with in Part X. (Estimate of Annual Costs and Revenue).

ORGANISATION AND METHOD OF SETTLEMENT.

Importance.

The proposals put forward in this report are the result of a considerable amount of investigation of the engineering and agricultural aspects of the scheme, by the Irrigation and Water Supply Commission, Bureau of Investigation, and Department of Agriculture and Stock.

Further detailed investigations, carried out concurrently with construction, will be required to complete the designs of the irrigation and drainage works.

However, the ultimate success of the project will depend very largely on the settlers who actually take up the land and produce the crops for which the scheme will provide the irrigation water.

Should these settlers fail through lack of ability, insufficient finance, or inadequate knowledge of irrigation farming methods then the careful and detailed investigation and planning of the engineering and agricultural aspects of the scheme will have been wasted.

It is obvious, therefore, that the matters of organisation, planning, and methods of settlement demand no less attention than are given to the other aspects of the scheme.

Factors Requiring Attention.

The factors affecting settlement which require attention include—

(*a*) Availability of settlers;

(*b*) Selection and training of settlers;

(*c*) Financing of farm development works;

(*d*) Organisation of farm development works;

(*e*) Provision of advisory and demonstration service to settlers to encourage efficient and economical production;

(*f*) Provision of civic amenities and facilities such as schools, postal services, health and recreation facilities;

(*g*) Provision of local urban centres in which goods and services (stores, foodstuffs, &c.) will be available to settlers.

Availability of Settlers.

The present demand for land in all parts of Queensland, and particularly for land suitable for tobacco production in the Mareeba-Dimbulah area, indicates that there is a large number of potential settlers available.

Further there are at present some 1,200 applicants for War Service Land Settlement who have not yet been provided with farms.

Little difficulty is, therefore, expected in obtaining settlers, but it is important that farms be taken up as soon as they can be provided with water, so that organisation of a "pool" of suitable settlers will be necessary.

Selection and Training of Settlers.

It is recognised that in all types of farming a "good" farmer will frequently succeed where a "poor" farmer under similar circumstances will fail.

In irrigation farming the small farm areas utilised as a result of intensive land use leave little margin for inefficient farm management and thereby emphasise the difference between the good and poor farmer.

It will, therefore, be desirable to select only those who, from their experience or general ability, would appear to be likely to succeed.

In addition, due to the small area irrigated in the State it cannot be expected that many potential settlers will be experienced irrigation farmers, and some training of settlers will be necessary to ensure they are at least acquainted with the fundamental principles of irrigated production.

Financing of Farm Development.

As farms will have to be developed largely from "virgin" country, liberal finance to settlers will be necessary. This will, no doubt, normally be available through the Agricultural Bank, but in view of the large numbers of farmers to be accommodated, strong and responsible representation of the Bank in the area will be necessary to facilitate and expedite finance.

Organisation of Farm Development.

The large numbers of farms to be developed each year will create heavy demands for labour and materials for building, fencing, and other works and for labour and equipment for land clearing and preparation.

Under present conditions of shortage of materials and equipment, assistance by bulk procurement by Government Departments of these items may be necessary, and the letting of large-scale contracts may warrant consideration.

Provision of Advisory Services.

Intensive land use under irrigation invariably creates problems in production. The establishment of experimental and demonstration farms in the area to study these problems is necessary. Combined with these farms the provision of an advisory or extension service to pass on the results of experiments to farmers is required so that they will maintain efficient and economical production.

Provision of Civic Amenities and Urban Centres.

The retention of settlers in the area will require provision of reasonable civic amenities, such as schools, health and postal services and recreation facilities in local urban centres, in which businesses can also be established to provide the needs of settlers, and the other persons dependent on rural employment. The provision and planning of local urban centres is discussed later under Urban Centres.

War Service Land Settlement.

The early stages of development of the project lend themselves to War Service Land Settlement purposes, in that the settlement provided will under irrigation ensure a sound return from agricultural production and provide a high standard of rural development adjacent to suitable urban facilities and amenities.

Use of the project for this purpose will also enable the existing organisation of War Service Land Settlement to be utilised in control, organisation, and finance of settlement.

It is considered that for Alternative A the whole of Stage 1 could be utilised in this way, providing as indicated in Table 38, Part VIII. (Construction and Development Programme) and in Table 31, Part V. (Proposed Development), a total of 662 tobacco farms, commencing with the opening of at least 32 excluding retention areas, in 1956-57 and completing the development in 1962-63.

In Alternative B, it is considered that the areas set out hereunder, containing the numbers of farms shown which exclude retention areas, could be utilised for War Service Land Settlement.

—	Tobacco.	Mixed agriculture.	All types.
Left Bank Atherton Creek	21	7	28
Right Bank Granite Creek	61	54	115
Left Bank Walsh ..	156	33	189
Right Bank Walsh ..	296	6	302
Total	534	100	634

Modification of the programme set out in Table 39, Part VIII. (Construction and Development Programme) as indicated, by providing for storage in Tinaroo Falls reservoir during construction of the dam, would permit opening of farms to commence in 1956-57 and completion of the above development in 1963-64.

It should be noted that opening of farms implies opening for production in the year indicated. In the case of tobacco farms this would mean production in August to December and would require actually placing settlers on the farms in December of the previous year.

URBAN CENTRES.

The existing town of Mareeba and the township of Dimbulah will provide a firm basis for the development of local urban centres. In each case, however, considerable expansion of these centres must result, and, if the scheme proceeds, early action on planning of development of these centres is necessary, particularly in the case of Dimbulah, which can be expected to expand considerably as a result of development around it.

In addition to these main urban centres, smaller local centres will be provided for at intervals of 7 to 10 miles in the redesign of the subdivision.

Full advantage should be taken of the excellent opportunity afforded by the resubdivision and close settlement of the area to provide for modern well-planned urban centres. Only by such planning can it be expected that such centres will attract the permanent residents and businesses required to provide the necessary farm labour to assist in crop production and the goods and services needed by farmers and their families.

ROADS.

As the opening of new farms will be on a perpetual lease tenure, it will be the responsibility of the Land Administration Board to develop the road system throughout the area to reasonable pioneer standards, which will entail clearing, grubbing, forming, and light surfacing and drainage. After completion to this stage roads will be handed over to the municipality for further development, financed through normal municipal revenue channels. Provision has been made in the estimate of cost of the project (see Part IX., Estimate of Cost) for such initial development of the road system. Encouragement should be given to the municipality to develop such roads to all-weather standards throughout the area as soon as possible, in order to provide satisfactory access to farms and for operation and maintenance of engineering works. As far as possible initial development of roads should be provided before works commence, as this will greatly facilitate construction and reduce costs of engineering and farm development works.

ELECTRICAL RETICULATION.

Electric power is already available in the Mareeba area, and with the gradual development of the Tully Falls Hydro-Electric Scheme it is expected that the Cairns Regional Electricity Board will provide early reticulation of electricity throughout the area.

Such provision will do much to improve the standard of living on the farms and in local urban centres and thus assist in retaining population in the area. No provision has been made in the estimate of cost for electrical reticulation except at Nullinga and Tinaroo Falls Dams, as it is expected that such work would be carried out in the normal manner by the Cairns Regional Electricity Board.

USE OF EXISTING WEIRS.

Pending completion of detailed investigations of irrigation works, the use which can be made of existing weirs and weirs under construction cannot be finally determined.

It is expected that these weirs will be most useful in the ultimate development of the area by providing balancing storages for the retention of overflows from the main channel systems and allowing such overflow to be utilised either by pumping to local reticulation systems or by private diversion.

The additional storage thus obtained together with interception of channel overflows will improve the efficiency of water utilisation and permit some additional irrigation development the extent of which will only be determined after some experience in operation of the area.

In the case of Bruce Weir it is expected that this storage will be required mainly for urban supply to the town of Dimbulah, the population of which could increase to from 3,000 to 5,000.

PART VI.—IRRIGATION WORKS.

GENERAL.

The proposed irrigation works consist of a system of main channels, one from each of the proposed reservoirs, to convey water by gravity to each of the individual sections of the project to be supplied, and further systems of reticulation channels within each section to convey water to individual farms within these sections. In addition to the areas to be supplied by gravity, the three areas, Paddy's Green, Springmount, and Nardello's Lagoon, situated above the channel systems, are proposed to be served by pumping as indicated in Part V. (Proposed Development).

The interconnection of the North Walsh and West Barron Main Channels also referred to in Part V. (Proposed Development) will thus permit supply of a large portion of the area from either storage, thus providing considerable flexibility in the utilisation of the water from each of these reservoirs, and in the case of Stage 1, Alternative B, connection to the South Walsh Main will enable the whole area to be commanded from Tinaroo Falls reservoir.

LOCATION.

Main Channels.

A tentative location of the main channel system serving the individual sections and shown on plans (Figs. 2 and 3) has been made on the information available. Except for some 60 miles of preliminary grade line on the North Bank Walsh Channel, all other locations are tentative only.

Reticulation Systems.

The information available does not justify any attempt to fix locations of reticulation systems within individual areas, but is generally sufficient to indicate that these areas can be satisfactorily reticulated.

Alternative Locations.

Several alternative locations for the main channel systems are evident, but detailed investigation of these alternatives is not justified until more information is obtained.

CHANNEL CAPACITIES.

Main Channels.

For the supply of tobacco areas, a weekly delivery of 3 inches of water to 10 acres (2·5 acre feet) is required to each farm of average area 50 acres. This rate of supply corresponds to "delivery of water rights in 105 days" and this basis is considered to be adequate for supply to other types of farms. This basis allows for delivery at the rate of 11 acre feet and 28 acre feet per week to mixed agriculture and pasture farms respectively and is considered ample to allow for any peak demands likely to occur on the main channel systems.

Reticulation Systems.

Capacities for reticulation systems have not been determined but the basis used for main channel capacities will generally be adopted, subject to provision of additional capacity to allow for the distribution of water on the rotation principle referred to under Water Distribution.

Distribution Efficiencies.

Main Channels.

For all main channels, capacities have been fixed at twice that required on the basis set out above to allow for distribution losses of 50 per cent. between storages and farm boundaries.

Reticulation System.

A higher value of distribution efficiency—up to 80 per cent. for concrete lined channels is proposed for reticulation systems.

Stage Development.

All channels for Stage 1 development for each alternative would be constructed to sufficient capacity to provide for areas served and water right allocations for Stage 2 development.

Additional Capacities.

Provision has been made in the capacities adopted—and indicated in Figs. 6 and 7—for expansion of the project to include full development of pasture lands available in the Left Bank Walsh Area.

Sufficient capacity has been allowed in both the North Walsh and West Barron Main Channels to permit supply from either of the reservoirs to the whole area common to both of these systems, to ensure full flexibility of supply from either storage.

WATER DISTRIBUTION.

Continuous Supply.

It must be clearly understood that the extensive channel system proposed for the development of the project, involving some 200 miles of main channels alone, will make it essential to distribute water continuously during irrigation periods—i.e., on a 24-hour day basis.

The main channel system alone will require a number of days to fill with water from the storages, and any attempt to regulate supplies for daylight watering would result in continuous fluctuations of channel levels and chaotic irregularities of supplies to irrigators.

It is considered that by careful attention to block layout, provision of suitable head ditches, regulators, and ditch outlets that watering can continue through hours of darkness without attention. Some slight irregularity of application must result but tobacco production is not likely to be affected.

If production is found to be unsatisfactory, however, irrigators may be obliged to arrange for production of less sensitive crops simultaneously with tobacco to provide for water utilisation during hours of darkness.

Continuous supply is general in all extensive irrigation areas elsewhere.

All channel capacities have been designed on the basis of continuous delivery to farms (24 hours per day) during each period of delivery to the farm.

Irrigation Periods.

A tentative rotation system of distribution, in which water is available to irrigators for regular periods and at regular intervals, has been adopted. This method will facilitate management, ensure orderly delivery, and avoid excessive peak demands on the system.

Supply to farms will be arranged on the rotational basis to provide water at periods not exceeding 1 week to tobacco farms and 15 days for other farms.

The system proposed is given in Table 33.

TABLE 33.

TENTATIVE ROTATION SYSTEM OF WATER DELIVERIES.

Land Use.	Maximum rate of delivery at farm.	Rotation period.	Days water available during rotation period.	Days between successive irrigations.
	Cusecs.	Days.		
Tobacco	1·07	6	1	5
Mixed agriculture	1·14	15	5	10
Pastures	2·86	15	5	10

Metering of Supply to Farms.

All supply to farms will be metered by means of Dethridge meter wheels, to enable charges for water to be based on quantities supplied and to facilitate equitable distribution in periods of short supply. The use of meters will assist irrigators in controlling water applied to land and in achieving efficient and economical use of water as well as providing vital statistical information on water usage and distribution efficiency needed as a guide in operation and management of this project and in design of future projects.

Annual Water Requirements.

The areas irrigated annually and maximum water requirements for the areas to be developed, as set out in Tables 28 and 29 Part V. (Proposed Development), for each stage of development and each of the alternatives, are set out in Table 34 for the two alternative schemes.

TABLE 34.

ANNUAL AREAS IRRIGATED AND MAXIMUM ANNUAL WATER REQUIREMENTS.

Stage.	Land Use.	Alternative A.				Alternative B.			
		Total farm areas.	Area irrigated.	Water requirements.		Total farm areas.	Area irrigated.	Water requirements.	
				At farm.	At storage.			At farm.	At storage.
		Acres.	Acres.	Acre feet.	Acre feet.	Acres.	Acres.	Acre feet.	Acre feet.
1 ..	Tobacco and vegetables	38,400	12,288	24,960	49,920	59,000	28,320	57,525	115,050
	Mixed agriculture	..	..	..	..	19,200	9,600	24,960	49,920
Total..	..	38,400	12,288	24,960	49,920	78,200	37,920	82,485	164,970
1 and 2	Tobacco and vegetables	59,000	28,320	57,525	115,050	59,000	28,320	57,525	115,050
	Mixed agriculture	26,640	13,320	34,632	69,264	26,640	13,320	34,632	69,264
	Pastures	11,800	5,900	15,340	30,680	11,800	5,900	15,340	30,680
Total..	..	97,440	47,540	107,497	214,994	97,440	47,540	107,497	214,994

CHANNEL CLASSIFICATION AND TYPES.

Classification.

In order to assist in preparation of estimates of cost, main channels have been classified as those which—

(a) Have a capacity of 30 cusecs or over; or

(b) Those less than 30 cusecs capacity which traverse areas of soils not suitable for development, i.e., are carrier channels only.

Types.

The type of channel construction allowed for has been varied to suit topography and soils encountered in both main channel and reticulation systems.

The following forms of construction have been adopted:—

(a) Trapezoidal earth;
(b) Trapezoidal earth with clay lining;
(c) Trapezoidal concrete lined;
(d) Rectangular reinforced concrete box flume;
(e) Reinforced concrete pipe lines.

Earth Channels.

This type has been tentatively adopted for heavier soils where channel grades are relatively flat, cross slopes slight and rock or gravel is not likely to be encountered.

Clay-lined Channels.

A small section of channel through one of the medium soil types appears to be suitable for this type.

Concrete-lined Channels.

The high permeability of many soils will require the use of concrete-lined channels to avoid uneconomical and dangerous seepage losses. It is expected that reticulation systems through tobacco areas will require to be practically completely concrete-lined.

In some cases, where soils are normally suited to earth channels, grades have been found excessive and concrete-lined channels have been adopted as more economical than earth channels requiring numerous drop structures to maintain non-scouring velocities.

Reinforced Concrete Box Flume.

This form of construction has been adopted where steep side slopes occur or where rock is found close to the surface.

Reinforced Concrete Pipe Lines.

It is expected that substantial lengths of reinforced concrete pipe lines will be used instead of open channels in the reticulation systems, where favourable head conditions exist. This form of construction though high in capital cost has many advantages, including—

(*a*) Low depreciation and maintenance costs:

(*b*) Higher efficiency of distribution than open channels;

(*c*) Facility in regulation of distribution.

Type and Extent of Proposed Main Channel System.

The estimated lengths for various capacities and types of channel required for the two stages of development are given in Table 35 for the two alternative schemes.

TABLE 35.

CAPACITIES, TYPES, AND LENGTHS OF MAIN CHANNELS.

Stage.	Alternative A.							Alternative B.						
	Capacity.	Earth.	Clay lined.	Concrete lined.	Box Flume.	Concrete Pipe Lines.	Total.	Capacity.	Earth.	Clay lined.	Concrete Lined.	Box Flume.	Concrete Pipe Lines.	Total.
	Cusecs.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.	Cusecs.	Miles.	Miles.	Miles.	Miles.	Miles.	Miles.
1	400–651	4·0	..	..	7·0	..	11·0	400–651	7·5	..	1·0	10·5	..	19·0
	250–400	..	..	..	..	1·5	1·5	250–400	..	..	9·0	..	1·5	10·5
	150–250	2·5	..	4·5	..	..	7·0	150–250	4·0	..	4·5	8·0	4·0	20·5
	100–150	8·6	2·2	18·8	6·4	..	36·0	100–150	8·6	2·2	24·8	6·4	..	42·0
	75–100	13·6	..	20·6	..	..	34·2	75–100	13·6	..	28·4	..	..	42·0
	50–75	6·1	..	11·5	..	..	17·6	50–75	13·0	..	19·3	3·3	..	35·6
	30–50	3·5	..	9·0	..	..	12·0	30–50	3·5	..	16·0	..	..	19·5
								Under 30	4·0	..	4·0	..	..	8·0
Total Stage 1	..	38·3	2·2	64·4	13·4	1·5	119·8	..	54·2	2·2	107·0	28·2	5·5	197·1
1 and 2 ..	400–651	7·5	..	1·0	13·0	..	21·5							
	250–400	..	..	9·0	..	1·5	10·5							
	150–250	2·5	..	4·5	..	..	7·0							
	100–150	8·6	2·2	24·8	6·4	..	42·0							
	75–100	13·6	..	28·4	..	..	42·0							
	50–75	13·0	..	19·3	3·3	..	35·6							
	30–50	3·5	..	16·0	..	..	19·5							
	Under 30	4·0	..	4·0	..	..	8·0							
Total Stages 1 and 2 ..	..	52·7	2·2	107	22·7	1·5	186·1							

All main channels would be constructed in Stage 1 for Alternative B with the exception of the first 2½ miles of the North Walsh Main.

STRUCTURES.

Both main channels and reticulation systems will require numerous regulator, offtake, and overflow structures and also a number of special measuring structures at key points to enable adequate control of distribution. Many bridges and culverts will be necessary to provide for road and access crossings on channels.

Several major syphons will be necessary where channel lines cross large depressions or main streams. These include, on the North Walsh Main, a syphon crossing some 1½ mile long across the saddle between the Walsh and Barron catchments south of the Paddy's Green area, and on the East Barron Main across the Barron River some 11 miles below Tinaroo Falls dam site. All structures will be constructed in reinforced concrete.

PUMPING STATIONS.

As indicated in Part V. (proposed Development), pumping stations will be required to supply the Paddy's Green (pumped) and Nardello's Lagoon areas and for Alternative A the Springmount area. These stations have not been designed, but tentative sites of stations have been fixed with a view to economy in capital cost of stations, rising mains, and channel reticulation systems as well as pumping costs.

It is proposed that the pumping units be electrically driven and arranged to operate unattended except for starting, stopping, and regulation. Power is expected to be available from the Cairns Regional Electricity Board transmission system.

Estimates of pump capacities allowing for 80 per cent. distribution efficiency between pump and farm boundares, static heads, and power requirements for the various stations and stages of development are given in Table 36.

TABLE 36.

PUMP CAPACITIES, STATIC HEADS, AND POWER REQUIREMENTS.

Area.	Station No.	Capacity.	Static head.	Power required.
		Cusecs.	Feet.	kW.
Paddy's Green	1	9	100	127
Paddy's Green	2	2·5	100	36
Paddy's Green	3	13	200	367
Paddy's Green	4	6	100	85
Nardello's Lagoon	1	4	130	74
Springmount (Alternative A only)	1	12	60	102

CONTROL OF STORM WATER DRAINAGE.

Only a small portion of the main channels is located on the crests of ridges, most of the system being on sidling country with large steep catchments above the channel lines.

Tropical rainfall of high intensity frequently occurs in the area during the wet season, and will cause heavy runoff from the catchment areas above the channel lines and will present a major hazard to the safety of the distribution system.

Protection of the works by provision of catch drains, subways, syphoning or fluming of channels across gullies and creeks. and location of overflow structures to discharge surplus flows in channels will be necessary and has been allowed for in the estimate of cost of the system.

ESTIMATE OF COST.

A preliminary estimate of the cost of the irrigation works has been prepared on the following basis:—

Main Channels.

Location and lengths determined on paper location only.

Type determined on topographical and soil map information available. No borings yet made along channel lines to ascertain soil conditions.

Sizes to conform to capacities determined as indicated under Channel Capacities and grades optained from paper location.

Estimated costs per mile of typical channel sizes determined from the above information.

Estimates of cost of major structures were determined after preparation of preliminary designs of all crossings required over creeks named on Military maps. Crossings of other gullies have been allowed for under minor structures.

The estimated cost of minor structures was determined by an allowance per mile of each individual channel type and size, based on estimated requirements of each type of structure per mile of channel.

Reticulation Systems.

Insufficient information is available to prepare detailed layouts, design, and estimates for the reticulation systems within the individual areas of the project.

However, estimates have been based on costs per acre of systems in other areas for which detailed designs and estimates have recently been prepared by the Commission.

Reticulation systems have been divided into two groups—concrete lined and earth channel systems and appropriate unit costs per acre served adopted for each type.

Concrete Lined Channel Systems.

These systems have been adopted for all tobacco areas, for type 15 (agriculture) soils (see Fig. 23), and in the Nardello's Lagoon (pumped) area. Cost per acre for these systems has been estimated at £52 per acre of farm areas served, which includes all channels and structures.

Earth Channel Systems.

This type of system has been adopted in most of the type 1 soil areas (mixed agriculture) (see Fig. 23) and all pasture areas. Cost per acre for these systems has been estimated at £19 10s. per acre of farm areas served, which includes all channels and structures.

Pumping Stations.

Separate preliminary estimates have been prepared for pumping stations.

Total Cost and Areas Served.

The total estimated cost of the various sections of the works, and the farm areas served for the two stages of development, are given in Table 37 for the two alternative schemes.

TABLE 37.

IRRIGATION WORKS—ESTIMATED COST AND AREAS SERVED.

Stage.	Alternative A. Capital Cost.							Alternative B. Capital Cost.						
	Main Channels.	Reticulation systems.	Pumping stations.	Roads, land resumptions and surveys.	District establishments.	Total.	Per acre served.	Main Channels.	Reticulation systems.	Pumping stations.	Roads, land resumptions and surveys.	District establishments.	Total.	Per acre. served.
	£	£	£	£	£	£	£	£	£	£	£	£	£	£
1 ..	3,070,000	1,996,800	..	522,100	133,750	5,652,650	147·2	5,400,000	3,640,000	78,000	960,700	204,750	10,154,950	130·0
2 ..	1,530,000	2,078,180	91,000	544,100	98,750	4,287,030	72·7	..	434,980	..	145,500	27,750	599,730	31·1
1 and 2	4,600,000	4,074,980	91,000	1,066,200	232,500	9,939,680	104·0	5,400,000	4,074,980	78,000	1,106,200	232,500	10,754,680	110·4

The cost of irrigation works per acre of farm area served is rather high and is affected by—

(*a*) The long length of main channel per acre served;

(*b*) The necessity for using a high proportion of concrete flume and lined channel sections in main and reticulation systems;

(*c*) The relatively large capacity of channels required to provide a high frequency of supply to tobacco farms.

PART VII.—DRAINAGE WORKS.

The success of irrigation projects has been found to depend largely on the provision of satisfactory drainage facilities for the removal of surplus storm and irrigation water to avoid soil deterioration and consequent production loss. In effect, the provision of adequate drainage works serves to safeguard capital invested in irrigation works and farm development by avoiding damage from—

(*a*) Water-logging of irrigated soils with consequent decrease in immediate yield, and

(*b*) Raising of the water table causing the deposition of harmful concentrations of salts in the root zone of the plants.

Provision of drainage works during the development period can be made at lower cost than is the case if these works are deferred until drainage troubles occur, and in addition avoids loss of production during the period required to construct such works after damage has commenced.

It is therefore proposed that suitable drainage works be provided for in the development of the Mareeba-Dimbulah Project.

GENERAL DESCRIPTION.

Generally the topography of the area is comparatively steep and this, together with the high intensity of rainfall characteristic of the area, will result in relatively large runoffs to be discharged by the drainage system. The drainage pattern of the area is, however, well defined, and the occurrence of creeks and watercourses, full use of which will be made in the location and design of the works, will facilitate provision of adequate drainage facilities.

In general each area within the major project will be served by a system of drains following natural depressions and discharging into watercourses and creeks, which in turn will deliver drainage water to the Barron and Walsh Rivers. Discharges from external catchment areas will require to be intercepted in some places and carried into natural watercourses to avoid flooding within the developed area.

Proper treatment of catchments within and without developed areas to reduce runoff will be essential not only to avoid damage to the developed areas but also to mimimise maintenance of the drainage system. In some cases it is expected that natural watercourses will require improvement by clearing, straightening, and treatment of eroded banks.

DESIGN.

The capacity of each drainage system will be designed to cope with storm water runoff only, as the amount of irrigation water discharged into the system will be negligible compared with storm water runoff.

Rainfall Intensity.

An intensity of 10 inches of rainfall per day is proposed as the basis of design.

Runoff.

It is proposed that the system shall be designed to allow for runoff from the above rainfall intensity over a period of 48 hours allowing for some local ponding over this period. Information available indicates that provision for higher rate of runoff cannot be economically justified at present.

Type of Works.

Drains.

The drains will consist of open earth channels of the conventional trapezoidal shape located to provide service to each farm. Inlets to drains will be through pipe line inlets under the banks of the drain, the size of pipe being restricted to that which will carry the runoff from the farm area determined on the basis indicated above.

Structures.

All structures will be of reinforced concrete, thus providing long life and low maintenance costs.

Estimate of Cost.

No attempt has been made to locate and design any section of the proposed drainage systems, but estimates have been prepared on the basis of the cost per acre for similar areas where detailed designs and estimates have recently been prepared by the Commission. Details of capital costs are given in Part IX. (Estimate of Capital Cost). Estimates of annual costs and operation have also been prepared and are given in Part X. (Estimate of Annual Cost).

PART VIII.—CONSTRUCTION AND DEVELOPMENT PROGRAMME.

Based on the information available at present a tentative construction and development programme has been prepared for the two stages of the project.

Details of this programme, covering construction of dams, irrigation works, drainage works, and opening of farms, is set out in Table 38 below for Alternative A, and Table 39 for Alternative B.

The programme has been prepared on the assumption that construction of Stage 2 will follow that of Stage 1 in time to provide continuity of farm openings. If for any reason it is necessary to defer Stage 2, this may be done without interference to the arrangements for Stage 1 development.

In determining the programme for construction of irrigation and drainage works, the limiting factor is the rate at which farms can be developed and settled, and a rate of 100 farms per annum has generally been fixed as the initial limit, rising to 160 farms per annum in later years.

Factors such as availability of settlers, materials and equipment for farm development, possible rates of land clearing and preparation, road construction and provision of urban facilities and amenities will render the task of developing 100 farms per annum one of considerable magnitude, apart from the actual construction of irrigation works.

Another vital factor in controlling the rate at which works can proceed will be the progress of detailed soil surveys on which design and layout of irrigation works and subdivision will be based. Early attention to this work will be necessary if the proposed programme is to be adhered to.

TABLE 38.

ALTERNATIVE A.

ANTICIPATED CONSTRUCTION AND DEVELOPMENT PROGRAMME.

Storage Works—
Nullinga Dam—
Commence 1952–53
Complete 1957–58

Storage Works—
Tinaroo Falls Dam—
Commence 1958–59
Complete 1963–64

Irrigation, Drainage, and Farm Development Works.

Area.	Year.	Construction (No. of farms).		Farm openings (No. of farms).				
		Year.	Progressive total.	Tobacco.	Mixed agriculture.	Pasture.	All types Year.	All types Progressive total.
Stage 1—								
Left Bank Walsh to Eureka Creek	53–54	10	10	..	..	..	..	..
	54–55	40	50	..	..	..	..	..
	55–56	50	100	..	..	..	..	..
Left Bank Walsh to Eureka Creek ..	56–57	100	200	100	..	..	100	100
Left Bank Walsh, Eureka Creek to end, Right Bank Walsh to Five Mile Creek	57–58	100	300	100	..	..	100	200
Right Bank Walsh to Five Mile Creek ..	58–59	100	400	100	..	..	100	300
Right Bank Walsh to Five Mile Creek ..	59–60	100	500	100	..	..	100	400
Right Bank Walsh to 5 Mile Creek Paddy's Green commanded ..	60–61	140	640	100	..	..	100	500
North and South Biboohra, Southedge	61–62	128	768	140	..	..	140	640
	62–63	..	..	128	..	..	128	768
Stage 2—								
Right Bank Granite Creek Left Bank Atherton Creek, North Biboohra, Paddy's Green pumped ..	62–63	164	932	..	..	..	..	..
Left and Right Bank Emerald Creek, Clohesy, Paddy's Green pumped	63–64	162	1,094	164	..	..	164	932
Springmount, Right Bank Walsh Five Mile Creek to end, Four Mile Creek Left Bank Ada Creek, Nardello's Lagoon	64–65	156	1,250	162	..	..	162	1,094
Mareeba, Left Bank Walsh to Eureka Creek, Right Bank Rocky Creek, South Biboohra, Southedge ..	65–66	162	1,412	82	74	..	156	1,250
Right and Left Bank Emerald Creek, Right Bank Walsh, Right and Left Bank Granite Creek, Paddy's Green commanded, Left Bank Atherton Creek	66–67	160	1,572	4	158	..	162	1,412
	67–68	..	..	..	101	59	160	1,572

TABLE 39.

ALTERNATIVE B.

ANTICIPATED CONSTRUCTION AND DEVELOPMENT PROGRAMME.

Storage Works—

Tinaroo Falls Dam—

Commence 1954–55

Complete 1959–60

Nullinga Dam—

Commence 1963–64

Complete 1968–69

Irrigation, Drainage and Farm Development Works.

Area.	Year.	Construction (No. of farms).		Farm openings (No. of farms).				
		Year.	Progressive total.	Tobacco.	Mixed agriculture.	Pasture.	All types Year.	All types Progressive total.
Stage 1—								
Right Bank Granite Creek	55–56	10	10	..	..	..	..	..
Right Bank Granite Creek	56–57	40	50	..	..	..	..	..
Right Bank Granite Creek, Left Bank Atherton Creek, Springmount	57–58	50	100	..	..	..	..	..
Right Bank Walsh to Murphy's Creek, Left Bank Walsh to Eureka Creek	58–59	100	200	100	..	..	100	100
Left Bank Walsh to Eureka Creek ..	59–60	100	300	100	..	..	100	200
Left Bank Walsh to Eureka Creek, Right Bank Walsh, Murphy's Creek to Five Mile Creek	60–61	100	400	100	..	..	100	300
Right Bank Walsh, Murphy's Creek to Five Mile Creek	61–62	100	500	100	..	..	100	400
Right Bank Walsh, Murphy's Creek to Five Mile Creek	62–63	138	638	100	..	..	100	500
Paddy's Green commanded, Southedge	63–64	132	770	138	..	..	138	638
Paddy's Green pumped, South Biboohra	64–65	167	937	132	..	..	132	770
North Biboohra, Left Bank Emerald Creek, Right Bank Emerald Creek, Clohesy	65–66	173	1,110	167	..	..	167	937
Right Bank Walsh, Five Mile Creek to end, Four Mile Creek, Nardello's Lagoon, Left Bank Ada Creek, Mareeba	66–67	160	1,270	173	..	..	173	1,110
Mareeba, Right Bank Rocky Creek, South Biboohra, Southedge .. Left Bank Walsh to Eureka Creek Right Bank Granite Creek ..	67–68	150	1,420	70	90	..	160	1,270
	68–69	..	..	..	150	..	150	1,420
Stage 2—								
Left Bank Granite Creek, Right Bank Granite Creek, Left Bank Emerald Creek, Right Bank Walsh, Paddy's Green commanded, Left Bank Atherton Creek	68–69	152	1,572	..	..	..	..	..
	69–70	..	..	..	93	59	152	1,572

Modification of Alternative B—Stage 1.

Storage during Construction of Tinaroo Falls Dam.

In order to simplify the comparison of the two alternative schemes it has been assumed that water cannot be supplied until the dam in each case is completed.

However, the adoption of the concrete dam proposed at Tinaroo Falls permits of arranging the construction programme in such a manner that water can be stored during construction.

This would make possible the delivery of water to portion of the area as soon for Alternative B as for Alternative A, i.e., in 1956-57.

Weir on Walsh River.

The construction of the weir on the Walsh River at 167M and of a connecting channel from this weir to the South Walsh Main Channel and construction of the South Walsh Main Channel would permit supply from the weir by gravity to farms in the Left Bank Walsh area now dependent largely on dry farming.

Under these conditions supply to these farms would be possible at an earlier date than for Alternative A—Stage 1.

PART IX.—ESTIMATE OF CAPITAL COST.

Estimates have been prepared of the capital cost of the project for the two stages of development for each alternative.

These estimates have been prepared on the bases indicated in the various sections of the report dealing with storages, irrigation works, drainage works and proposed development, and for costs as at 30th September, 1951.

Because detailed surveys are still in progress these estimates must be regarded as being approximate, but sufficiently accurate to show the relative merits of the proposals.

The estimates of capital cost of the project for each alternative are as follows:—

ALTERNATIVE A.

ESTIMATE OF CAPITAL COST.

	£	£	£
Stage 1—			
Nullinga Dam		7,166,000	
Main channels		3,070,000	
Irrigation works— 768 farms at £2,600 per farm		1,996,800	
Drainage works— 768 farms at £650 per farm		499,200	
Office and staff accommodation		133,750	
Road works in irrigation areas; Land resumption (irrigation area); Surveys ..		522,100	
			13,387,850
Stage 2—			
Tinaroo Falls Dam		7,830,000	
Main channels		1,530,000	
Irrigation works—			
Tobacco farms— 412 at £2,600 per farm	1,071,200		
Mixed agriculture farms— 99 at £4,160 per farm	411,840		
234 at £1,560 per farm	365,040		
Pasture farms— 59 at £3,900 per farm	230,100		
		2,078,180	
Drainage works—			
Tobacco farms— 412 at £650 per farm	267,800		
Mixed agriculture farms— 333 at £1,040 per farm	346,320		
Pasture farms— 59 at £2,600 per farm	153,400		
		767,520	
Pumping stations		91,000	
Office and staff accommodation		98,750	
Road works in irrigation areas; Land resumption (irrigation area); Surveys ..		544,100	
			12,939,550
			£26,327,400

The cost given for main channels in Stage 1 of Alternative A includes the additional expenditure of £1,370,000 necessary to provide the capacity required in those channels which will later form part of Stage 2.

If only Stage 1 were constructed, the cost of it would be reduced to £12,017,850. There would be a corresponding increase in the cost of Stage 2 if it were constructed subsequently.

ALTERNATIVE B.

ESTIMATE OF CAPITAL COST.

	£	£	£
Stage 1—			
Tinaroo Falls Dam		7,830,000	
Main channels		5,400,000	
Irrigation works—			
Tobacco Farms— 1,180 at £2,600 per farm ..	3,068,000		
Mixed agricultural farms— 76 at £4,160 per farm	316,160		
164 at £1,560 per farm	255,840		
		3,640,000	
Drainage works—			
Tobacco farms— 1,180 at £650 per farm	767,000		
Mixed agriculture farms— 240 at £1,040 per farm	249,600		
		1,016,600	
Pumping stations		78,000	
Office and staff accommodation		204,750	
Road works in irrigation areas; Land resumption (irrigation area); Surveys ..		960,700	
			19,130,050
Stage 2—			
Nullinga Dam		7,166,000	
Irrigation works—			
Mixed agriculture farms— 23 at £4,160 per farm	95,680		
70 at £1,560 per farm	109,200		
Pasture farms— 59 at £3,900 per farm	230,100		
		434,980	
Drainage works—			
Mixed agriculture farms— 93 at £1,040 per farm	96,720		
Pasture farms— 59 at £2,600 per farm	153,400		
		250,120	
Office and staff accommodation		27,750	
Road works in irrigation areas; Land resumption (irrigation area); Surveys ..		145,500	
			8,024,350
			£27,154,400

The estimates are summarised in Table 40 for the two alternative schemes.

TABLE 40.

SUMMARY OF ESTIMATED CAPITAL COST.

Item.	Alternative A.			Alternative B.		
	Stage 1.	Stage 2.	Total.	Stage 1.	Stage 2.	Total.
	£	£	£	£	£	£
Storages	7,166,000	7,830,000	14,996,000	7,830,000	7,166,000	14,996,000
Main channels	3,070,000	1,530,000	4,600,000	5,400,000	..	5,400,000
Irrigation works	1,996,800	2,078,180	4,074,980	3,640,000	434,980	4,074,980
Drainage works	499,200	767,520	1,266,720	1,016,600	250,120	1,266,720
Pumping stations	..	91,000	91,000	78,000	..	78,000
Office and staff accommodation..	133,750	98,750	232,500	204,750	27,750	232,500
Road works in irrigation areas, land resumptions (irrigation area), surveys	522,100	544,100	1,066,200	960,700	145,500	1,106,200
	13,387,850	12,939,550	26,327,400	19,130,050	8,024,350	27,154,400

NOTE.—Greater capital cost of Alternative B is due principally to Walsh Bluff Main Channel and syphon at Nullinga.

PART X.—ESTIMATE OF ANNUAL COSTS AND REVENUE.

ANNUAL COSTS.

Estimates have been prepared of the annual costs of the Project for each alternative at each stage of development.

The estimates include interest and redemption on the capital cost of the storage, irrigation and drainage works, and operation, maintenance, and administration costs for all works, including pumping stations.

Summaries of these costs for storage and irrigation works and district establishments (offices and housing, &c.,) are given in Table 41 for the two alternative schemes.

Summaries of costs for drainage works are given in Table 42 for the two alternative schemes.

Interest charges have been calculated at $4\frac{1}{2}$ per cent. and redemption at $\frac{3}{8}$ per cent. (a life of 50 years) for all works except district establishments on which redemption has been allowed at 2 per cent. (30 years).

TABLE 41.

ESTIMATED ANNUAL COSTS—STORAGE AND IRRIGATION WORKS.

Stage.	Section of works.	Alternative A.			Alternative B.		
		Operation, maintenance and administration.	Interest and redemption.	Total.	Operation, maintenance and administration.	Interest and redemption.	Total.
		£	£	£	£	£	£
1 ..	Storage	1,600	340,000	342,000	1,600	371,900	373,500
	Main channels and irrigation works	57,700	240,700	298,400	116,000	433,100	549,100
	Office and staff accommodation ..	5,300	7,900	13,200	8,200	12,000	20,200
	Road works, land resumptions, surveys	..	24,800	24,800	..	45,600	45,600
Total Stage 1		64,600	613,800	678,400	125,800	862,600	988,400
1 and 2	Storages	3,200	712,300	715,500	3,200	712,300	715,500
	Main channels, irrigation works, and pumping stations	130,400	416,400	546,800	130,000	453,800	583,800
	Office and staff accommodation ..	9,300	13,700	23,000	9,300	13,700	23,000
	Road works, land resumptions, surveys	..	50,600	50,600	..	52,500	52,500
Total Stages 1 and 2		142,900	1,193,000	1,335,900	142,500	1,232,300	1,374,800

TABLE 42.

ESTIMATED ANNUAL COSTS—DRAINAGE WORKS.

Stages.	Alternative A.			Alternative B.		
	Operation, maintenance and administration.	Interest and redemption.	Total.	Operation, maintenance and administration.	Interest and redemption.	Total.
	£	£	£	£	£	£
1	19,200	23,700	42,900	39,100	48,300	87,400
1 and 2	48,700	60,200	108,900	48,700	60,200	108,900

REVENUE.

Direct revenue from the project will be derived from—

Water right charges;
Water sales charges;
Land rentals;
Rentals on Commission dwellings;
Drainage charges.

Water Right Charges.

Water right charges have been tentatively fixed after consideration of the ability of the irrigator to meet the charges and on the basis that such charges should at least be sufficient to meet operation, maintenance, and administration costs.

Differentiation in water charges for the various types of production is considered necessary, because of the difference in frequency of supply required for the various forms of land use and the difference in relationship between water allocations and estimated value of production, which is indicated in Table 43, and to obtain some degree of uniformity of relationship between water charges and net returns from various types of land use.

TABLE 43.

ALLOCATION OF WATER AND GROSS VALUE OF PRODUCTION PER FARM.

Type of farm.	Water available water right plus sales.	Estimated gross annual value of production.
	Acre feet.	£
Tobacco (1) ..	32·5	4,600
Tobacco	48·7	5,400
Mixed agriculture..	104	2,400
Pasture	260	2,000

(1) Stage 1 Alternative A only.

As farm sizes will be fixed in accordance with suitability of soils for the various types of land use, and water rights will be allocated on the basis of the irrigable areas of farms, it is proposed to graduate charges in accordance with water right allocations. Charges per acre foot, farm areas, and total water charges are indicated in Table 44.

TABLE 44.

PROPOSED WATER CHARGES AND TOTAL COST OF WATER PER FARM.

Type of farm.	Average farm area.	Water right allocation.		Water charge per acre foot water right and sales.	Total annual water charge per average farm for water right and sales.
		Acre feet per acre.	Volume.		
	Acres.		Acre feet.	£ s. d.	£ s. d.
Tobacco (1)	50	½	Up to 70 ..	3 10 0	113 15 0
Tobacco	50	¾	Up to 70 ..	3 10 0	170 12 6
Mixed agriculture ..	80	1	70 to 140 ..	1 10 0	156 0 0
Pasture	200	1	Over 140 ..	1 0 0	260 0 0

(1) Stage 1, Alternative A only.

The tentative charges set out above are proposed to be uniform for areas supplied by gravity and from central pumping stations, the cost of pumping being spread over the whole project area.

Revenue from water rights will be a minimum annual charge, and will therefore be constant. The estimated revenue from this source is included in Table 46 for the two alternative schemes.

Water Sales Charges.

It is intended that water in excess of water rights will be supplied to farms when available and as required up to 30 per cent. of such water rights on a sales basis.

Charges for water sales are proposed to be similar to those for water rights. The amount of water supplied as sales will vary from year to year according to seasonal conditions and availability of water from storages.

Annual revenue from water sales has been taken as 15 per cent. of water rights (i.e., half full sales allowance), which corresponds closely to the following estimated deliveries over a 10-year period in which allowance is made for restriction of supplies from storage, reduced demand in wet years, and normal supplies in other years.

2 years—80 per cent. Water rights (supplies restricted);

2 years—Water rights only (low demand in wet years);

6 years—Water rights plus 30 per cent. sales (normal years).

Revenue from this source and on the above basis is included in Table 46 for the two alternative schemes.

Land Rentals.

Present land rentals from leasehold lands in the area are very low, while a considerable area is held on freehold tenure.

As the lands resumed and resubdivided will be opened on leasehold tenure, and as such land will be increased considerably in value by the provision of irrigation facilities, there will be a significant increase in the return from land rentals from the project area.

Using rentals for irrigated tobacco lands at Clare as a basis, the value of rentals for irrigable lands in the Mareeba-Dimbulah area are estimated as follows:—

Tobacco farms—10s. per acre;

Mixed agriculture farms—8s. per acre;

Pasture farms—6s. per acre.

The estimated value of existing and future rentals and the increase in this revenue following development of the project are given in Table 45 for the two alternative schemes.

TABLE 45.

ESTIMATED EXISTING AND FUTURE LAND RENTALS.

Stage.	Alternative A.			Alternative B.		
	Existing rentals.	Future rentals.	Increase in rentals.	Existing rentals.	Future rentals.	Increase in rentals.
	£	£	£	£	£	£
1	2,300	16,800	14,500	2,700	33,600	30,900
1 and 2	3,300	40,100	36,800	3,300	40,100	36,800

In estimating the annual revenue from the project the values of increased rentals set out in Table 45 above have been used in Table 46.

Rentals from Commission Dwellings.

Commission officers stationed in the area and provided with housing will, with the exception of water officers, be required to pay rentals, and the amounts shown in Table 46 for this item are in accordance with present practice, based on 10 per cent. of officers' salaries.

Drainage Charges.

Charges of 10s. per acre have been tentatively adopted. The revenue from this source for the two alternative schemes is included in Table 46.

Total Revenue.

Details of annual revenue derived from the various sources for the two stages of both alternatives are set out for irrigation works in Table 46 and for drainage works in Table 47.

TABLE 46.

ESTIMATED ANNUAL REVENUE—IRRIGATION WORKS.

Stage.	Alternative A.				Alternative B.			
	Water charges.	Increase in land rentals.	Rentals on dwellings.	Total.	Water charges.	Increase in land rentals.	Rentals on dwellings.	Total.
	£	£	£	£	£	£	£	£
1	77,300	14,500	4,100	95,900	211,200	30,900	5,900	248,000
1 and 2 ..	237,300	36,800	7,100	281,200	237,300	36,800	7,100	281,200

TABLE 47.

ESTIMATED ANNUAL REVENUE—DRAINAGE WORKS.

Stage.	Drainage Charges.	
	Alternative A.	Alternative B.
	£	£
1	19,200	39,100
1 and 2	48,700	48,700

PART XI.—BENEFITS FROM PROJECT AND FINANCE.

BENEFITS.

The main benefits to be derived from the project are—

- Increased population;
- Increased production from the area and consequent increase in national wealth;
- Increased revenue to State and Commonwealth Governments resulting from increased production and population.

Increased Population.

As far as can be ascertained, there are 1,500 rural and 3,000 urban dwellers in the areas to be developed by the two stages of the project.

Following development of the area, it is expected that, in addition to the farmer, each farm will require labour equivalent to the following number of men permanently employed:—

Tobacco farms	1½
Mixed agriculture farms	1
Pasture farms	1

and that there will be two dependents to each breadwinner.

This labour will be drawn from nearby rural areas or urban centres.

In addition, it is expected that local manufacturers and suppliers of goods and services, with their families, will provide local urban population equivalent to the increase in population dependent on rural employment.

The estimated total population after full development of each stage of the two alternative schemes is set out in Table 48.

TABLE 48.

ESTIMATED TOTAL POPULATION.

Stage.	Type of farm.	Alternative A.					Alternative B.				
		Number of farms.	Population dependent on rural employment.		Population dependent on urban employment.	Total.	Number of farms.	Population dependent on rural employment.		Population dependent on urban employment.	Total.
			Per farm.	Total.				Per farm.	Total.		
1 ..	Tobacco	768	7½	5,760	5,760	11,520	1,180	7½	8,850	10,290	20,580
	Mixed agriculture	..	..	..	..	..	240	6	1,440		
1 and 2	Tobacco	1,180	7½	8,850	11,202	22,404	1,180	7½	8,850	11,202	22,404
	Mixed agriculture and pasture ..	392	6	2,352			392	6	2,352		

The increased population for the two alternatives will therefore be as set out in Table 49.

TABLE 49.

ESTIMATED INCREASED POPULATION.

Stage.	Alternative A.							Alternative B.						
	Dependent on rural employment.			Dependent on urban employment.			Total increase.	Dependent rural employment.			Dependent on urban employment.			Total increase.
	Present.	Future.	Increase.	Present.	Future.	Increase.		Present.	Future.	Increase.	Present.	Future.	Increase.	
1 ..	1,500	5,760	4,260	3,000	5,760	2,760	7,020	1,500	10,290	8,790	3,000	10,290	7,290	16,080
1 and 2	1,500	11,202	9,702	3,000	11,202	8,202	17,904	1,500	11,202	9,702	3,000	11,202	8,202	17,904

There will also be consequential increases in the population of the larger cities.

Gross Value of Production.

An estimate of the gross annual value of production from the area after full development of the two stages of each alternative is set out in Table 50.

This estimate has been based on the following values of production per acre:—

Tobacco	£400
Vegetables	£100
Mixed agriculture	£60
Pasture (Stock fattening) ..	£20

TABLE 50.

ESTIMATED GROSS ANNUAL VALUE OF PRODUCTION.

Stage.	Type of farm.	Alternative A.						Alternative B.					
		Number of farms.	Crops.	Area irrigated per farm.	Value per acre.	Value of crop.	Total value.	Number of farms.	Crops.	Area irrigated per farm.	Value per acre.	Value of crop.	Total value.
				Acres.	£	£	£			Acres.	£	£	£
1 ..	Tobacco ..	768	Tobacco ..	10	400	3,072,000	..	1,180	Tobacco ..	10	400	4,720,000	..
	..	..	Vegetables ..	6	100	460,800	3,532,800	..	Vegetables ..	14	100	1,652,000	..
	Mixed agriculture	..	..	..	..	..	..	240	Cotton, maize, sunflower, cowpeas, &c.	40	60	576,000	6,948,000
1 and 2	Tobacco ..	1,180	Tobacco ..	10	400	4,720,000	..	1,180	Tobacco ..	10	400	4,720,000	..
	..	..	Vegetables ..	14	100	1,652,000	..	..	Vegetables ..	14	100	1,652,000	..
	Mixed agriculture	333	Cotton, maize, sunflower, cowpeas, &c.	40	60	799,200	..	333	Cotton, maize, sunflower, cowpeas, &c.	40	60	799,200	..
..	Pasture ..	59	Stock fattening	100	20	118,000	7,289,200	59	Stock fattening	100	20	118,000	7,289,000

The production from farms in the area at present is considerably less than the values estimated for farms in Table 50 above, due to limited water supplies for irrigation. The estimated value of present production for each alternative is set out in Table 51.

By the construction of Tinaroo Falls Dam an area of some 5,300 acres of land at present used for agricultural and dairying production will be submerged and the value of production from this area will be lost. The estimated value of production from this area is £257,000 per annum.

The estimated values of present and future production and increased value of production as a result of development of the project are set out for each alternative in Table 51.

TABLE 51.

ESTIMATED INCREASED ANNUAL VALUE OF PRODUCTION.

Stage.	Alternative A.				Alternative B.			
	Total value of production.	Value of existing production.	Loss of production Tinaroo Falls reservoir area.	Increased value of production.	Total value of production.	Value of existing production.	Loss of production Tinaroo Falls reservoir area.	Increased value of production.
	£	£	£	£	£	£	£	£
1	3,532,800	325,000	..	3,207,800	6,948,000	530,000	257,000	6,161,000
1 and 2 ..	7,289,200	580,000	257,000	6,452,200	7,289,200	580,000	257,000	6,452,200

Return to State and Commonwealth Governments.

It has been estimated that in Victoria farmers in irrigation areas expend 80 per cent. of the increased gross value of production in payment for goods and services, and that of the total value of production two fifths accrues to the State and Commonwealth Governments in water rates and other charges and in fares, freights, and taxes. Assuming that similar conditions will obtain in the Mareeba-Dimbulah project, the estimated annual return to the two Governments for each alternative will be as shown in Table 52.

TABLE 52.

INCREASED ANNUAL VALUE OF PRODUCTION AND ESTIMATED RETURN THEREFROM TO STATE AND COMMONWEALTH GOVERNMENTS.

Stage.	Alternative A.						Alternative B.					
	Capital cost.	Increased value of production.	Return to Commonwealth and State Governments.				Capital cost.	Increased value of production.	Return to Commonwealth and State Governments.			
			Total.	Water and drainage charges.	Indirect.	Per cent. on capital cost.			Total.	Water and drainage charges.	Indirect.	Per cent. on capital cost.
	£	£	£	£	£		£	£	£	£	£	
1	13,387,850	3,207,800	1,283,100	96,500	1,186,600	8·9	19,130,050	6,161,000	2,464,400	250,300	2,214,100	11·6
1 and 2 ..	26,327,400	6,452,200	2,580,900	286,000	2,294,900	8·7	27,154,400	6,452,200	2,580,900	286,000	2,294,900	8·4

It is expected that of the indirect return from the project, rather more than half is likely to accrue to the Commonwealth Government.

Volume of Production.

The volume of production from the project is of even greater importance to the community than the value in terms of money.

As indicated in Table 50 the production from tobacco farms will include tobacco and vegetables. Vegetables will no doubt include potatoes, pumpkins, tomatoes, beans, and salad vegetables. In assessing the volume of production from the area it has been assumed that the vegetable production would be 50 per cent. potatoes and 50 per cent. pumpkins.

Mixed agriculture farms are expected to produce cotton, maize, sunflower seed, cowpeas, and other general agricultural crops, but in assessing the volume of production from the project it has been assumed that mixed agriculture production would be 33⅓ per cent. cotton, 33⅓ per cent. maize, and 33⅓ per cent. cowpeas.

Pasture farms are expected to be utilised for dairying, beef fattening, and possibly fat lamb raising, but in assessing the volume of production from the project it has been assumed that production from pasture farms would be all fat beef.

On the assumptions set out above the likely production from the project area for the two stages of each alternative is set out in Table 53.

TABLE 53.

ESTIMATED VOLUME OF PRODUCTION.

Stage.	Type of Farm.	Alternative A.					Alternative B.				
		Number of farms.	Crop.	Irrigated area.	Production per acre.	Total production.	Number of farms.	Crop.	Irrigated area.	Production per acre.	Total production.
				Acres.					Acres.		
1 ..	Tobacco ..	768	Tobacco ..	7,680	1,000 lb.	7,680,000 lb.	1,180	Tobacco ..	11,800	1,000 lb.	11,800 000 lb.
			Potatoes ..	2,304	4 tons ..	9,216 tons ..	..	Potatoes ..	8,260	4 tons ..	33,040 tons
			Pumpkins ..	2,304	4 tons ..	9,216 tons ..	..	Pumpkins ..	8,260	4 tons ..	33,040 tons
	Mixed agriculture	..	..	..	..	..	240	Cotton ..	3,200	1,200 lb.	3,840,000 lb.
	..	..	..	..	..	..	..	Maize ..	3,200	$1\frac{1}{2}$ tons	4,800 tons
	..	..	..	..	..	..	..	Cowpeas ..	3,200	15 bush.	48,000 bush.
1 and 2 ..	Tobacco ..	1,180	Tobacco ..	11,800	1,000 lb.	11,800,000 lb.	1,180	Tobacco ..	11,800	1,000 lb.	11,800,000 lb.
	..	..	Potatoes ..	8,260	4 tons	33,040 tons ..	..	Potatoes ..	8,260	4 tons	33,040 tons
	..	..	Pumpkins ..	8,260	4 tons ..	33,040 tons	..	Pumpkins ..	8,260	4 tons ..	33,040 tons
	Mixed agriculture	333	Cotton ..	4,440	1,200 lb.	5,328,000 lb.	333	Cotton ..	4,440	1,200 lb.	5,328,000 lb.
		..	Maize ..	4,440	$1\frac{1}{2}$ tons	6,660 tons ..	..	Maize ..	4,440	$1\frac{1}{2}$ tons	6,660 tons
	..	..	Cowpeas ..	4,440	15 bush.	66,600 bush.	..	Cowpeas ..	4,440	15 bush.	66,600 bush.
	Pasture ..	59	Fat cattle ..	5,900	3 beasts	17,700 beasts	59	Fat cattle ..	5,900	3 beasts	17,700 beasts

FINANCE.

Annual Costs and Revenue.

The estimated annual costs and revenue for each alternative are set out in Table 54.

TABLE 54.

ESTIMATED ANNUAL COSTS AND REVENUE.

Stage.	Alternative A.					Alternative B.				
	Annual Costs.			Direct revenue (irrigation and drainage charges and rentals).	Deficit.	Annual Costs.			Direct revenue (irrigation and drainage charges and rentals).	Deficit.
	Operation, maintenance and administration.	Interest and redemption.	Total.			Operation, maintenance and administration.	Interest and redemption.	Total.		
	£	£	£	£	£	£	£	£	£	£
1	83,800	637,500	721,300	115,100	606,200	164,900	910,900	1,075,800	287,100	788,700
1 and 2	191,600	1,253,200	1,444,800	329,900	1,114,900	191,200	1,292,500	1,483,700	329,900	1,153,800

National Works.

The creation of irrigation and water conservation works as national works has now been adopted as general policy in other States of Australia and in most other countries, as indicated as follows:—

Victoria.—Legislation provides for the declaration of free headworks on which maintenance, management, interest and redemption are met from consolidated revenue. Such headworks include water conservation works and irrigation works.

A Royal Commission (1937) on "The Expediency of Amending the Water Act and Other Matters," found that the amount of capital cost of works allotted to any district should be limited so that water and drainage charges could be maintained at a level that irrigators could be reasonably expected to meet. This principle has resulted in the whole of the capital cost of irrigation and drainage works in Victoria now being borne by the State.

New South Wales.—The whole of the capital costs of irrigation and drainage works in New South Wales is borne by the State.

South Africa.—In 1947 a Royal Commission on "Finance of Irrigation Works," following a close study of conditions in Australia, and of American legislation, recommended that the capital cost of all future irrigation works be borne completely by the South African Government.

America.—American policy with respect to irrigation and drainage works is that interest charges on capital costs are borne by the United States Government but provision is made for redemption of capital costs from revenue derived from the project generally over a period of 40 years but in some cases up to 100 years.

The position with respect to the Mareeba-Dimbulah project will be somewhat better than works in other States since, as indicated in Table 54, the annual direct revenue from the project is estimated to cover operation, maintenance, and administration costs and also to provide a substantial contribution to annual interest and redemption costs.

Although the annual deficit of revenue against annual costs will have to be borne by the State or State and Commonwealth Governments, the indirect return shown in Table 52 will be greatly in excess of the direct deficit, and will represent a considerable return upon the capital invested.

The major portion of the annual costs—other than for operation, maintenance, and administration—must necessarily be borne by Governments. Having regard to the saving of dollars by production of a large quantity of tobacco, the production of the greatly needed supply of foodstuffs and the increase in population of the North, the construction of the project wholly as a national work, upon which all capital charges will be met by the Government, is amply justified.

APPENDIX I.

HYDROLOGY.

RAINFALL.

The average annual rainfall varies from more than 90 inches along the Lamb Range in the east to less than 26 inches at Dimbulah in the west. There is a great range in the monthly rainfalls, the heaviest precipitation occurring during the three summer months. The mountain topography causes a wide variation throughout the area.

In the case of the proposed Tinaroo Falls Dam on the Barron River, there are 10 rainfall recording stations within the catchment area and two not far outside it. Because long-term records of streamflow were available, little dependence on rainfall records was necessary in estimating the yield from this reservoir.

In the case of the proposed Nullinga Dam, on the Walsh River, there was only one rainfall station, Watsonville (record 1938-48) within the catchment area but there were four stations, viz., Atherton, Herberton, Irvinebank, and Selby, not far outside it. Because of the meagre stream gauging records, it has been necessary to rely largely upon rainfall data in estimating the yield from this reservoir.

Isohyetal Map.

Atherton, Herberton, Irvinebank, and Mareeba had rainfall records extending over 55 years. No other stations had records exceeding 29 years and many had only very short records. In order to eliminate long period variations in rainfall, it was considered necessary to extend the shorter records to 35 years for the purpose of compiling an isohyetal map and estimating the average rainfalls.

The four long-period stations were adopted as key stations arranged in pairs (Atherton-Herberton and Mareeba-Irvinebank) and the mean of the annual rainfalls for each pair of stations, for the 35 year period 1915 to 1949, was used as a master record.

The ratio of the total rainfall for the years of actual record at each short-period station to that of each of the master records for the same period was determined and applied as a multiplying factor to the rainfall of the master records for each month and year to estimate the rainfall for the same months and years respectively over the period of no record at the short period stations.

Actual records of monthly rainfall for Atherton, Dimbulah, Herberton, Irvinebank, Mareeba, and Watsonville are given in Tables 61 to 66. Table 69 shows the average annual rainfall for each station for the period of 35 years, 1915 to 1949, as estimated by comparison with each of the master records. For any one station the difference between the two estimates was small and the mean of the two was accepted as the average annual rainfall for that station. Table 69 also shows the actual maximum and minimum annual rainfall and the maximum monthly rainfall for each station for the period of record.

These means were used in plotting the Isohyetal Map (Fig. 11), consideration being given to the effect of topography.

Average annual rainfall obtained from the isohyetal map is set out in Table 55.

TABLE 55.

CATCHMENT AREAS AND AVERAGE RAINFALLS.

—	Area.	Rainfall.
	(Square miles).	(inches).
Barron River above Picnic Crossing	88	52·5
Barron River above Tinaroo Falls	220	54·4
Barron River above Mareeba	332	51·3
Walsh River above Nullinga	124	42·6
Walsh River above Dimbulah	398	36·8

Monthly Rainfalls on Catchment Areas.

Average monthly rainfalls on the catchment area of the Walsh River above Nullinga Dam site were derived by multiplying the monthly value from a master record by a factor representing the ratio of the annual average rainfall over the catchment to the mean annual rainfall from a master record for the 35-year period 1915 to 1949. The factor for the Herberton-Atherton master record is 0.873 and that for Mareeba-Atherton master record in 1.310. The two sets of monthly values for the Nullinga catchment are set out in Tables 67 and 68.

As might be expected, there is some discrepancy between the two sets of monthly values. Those based upon the Herberton-Atherton master record are the lower and were adopted for estimating runoff.

Monthly rainfalls for the catchment of the Barron River were not worked out as they were not required.

INFLOW TO RESERVOIRS.

Tinaroo Reservoir.

Stream Gauging Records.—Stream gauging records for the Barron River are available as set out below:—

Station.	River mileage.	Catchment.	Period of record.	Remarks.
		Square miles.		
Kuranda (Hydro)	13·3	740	August, 1942, to date ..	..
Kuranda	14·2	736	August, 1915–November, 1941	See Table 72
Fairyland	15·4	728	November, 1941, to date	Several months missing, 1946–49
Mareeba	43·6	332	1916 to date	See Table 73
Picnic Crossing	78·9	88	1926 to date	See Table 74

The site of Tinaroo Dam is just upstream of 63 miles. The catchment area of 220 square miles is approximately the mean of the catchment areas at Picnic Crossing and Mareeba.

Estimation of Inflow.—For reservoirs which control a large proportion of the total runoff it is frequently found that the critical periods occur during a prolonged drought such as that of 1914-15, and, in the absence of stream gaugings, the runoff during such periods must be deduced from rainfall data.

In connection with a report to the State Electricity Commission in 1939 dealing with possible further development of hydro-electric power from the Barron River, the Chief Engineer of the Stanley River Works Board (Mr. W. H. R. Nimmo) investigated the relation of runoff to rainfall on the Barron catchment and computed monthly runoffs for the period 1911-36. The methods employed are described in detail in the report. It was found that the relationship between monthly rainfall and monthly runoff for the period of actual record was practically the same for Picnic Crossing and Mareeba. The monthly runoff at Tinaroo was taken as the mean of the values for Picnic Crossing and Mareeba. These values of runoff have been used in the present investigation up to 1936.

From the end of 1936 the flow at Tinaroo has been computed from the mean of the flows per square mile at Picnic Crossing and Mareeba. A comparison of flows at Picnic Crossing, Tinaroo, and Mareeba over the whole period indicates that this method produces somewhat more conservative results than that used for the earlier period.

Nullinga Reservoir.

Stream Gauging Records.—Stream gauging records for the Walsh River are available as set out below:—

Station.	River mileage.	Catchment.	Period of record.	Remarks.
		Sq. miles.		
Dimbulah	142·9	398	June, 1937, to June, 1950	See Table 70
Tabacum	158·6	169	August, 1948, to October, 1950	See Table 71

The figures for low-stage discharge have been derived from one or more current meter readings annually. Some measurements have been made during moderate freshes and these have been used in estimating high-stage discharges.

Estimation of Inflow.—There being no stream gauging records for Nullinga Dam Site, it has been necessary to estimate monthly runoff from the records available for Dimbulah and Tabacum.

A comparison of these records since August, 1948, indicates that the average surface runoff at Tabacum is 60 per cent. of that at Dimbulah. The catchment area above the dam site is 124 square miles, which is 75 per cent. of that above Tabacum. The intervening area is occupied principally by the catchment of Oakey Creek, having similar rainfall and topography to that above the dam site. Assuming that the runoff per square mile is the same for all portions of the catchment above Tabacum—a conservative assumption—the runoff at the dam site has been taken to be 45 per cent. of that at Dimbulah. The catchment area above the dam site is 31 per cent. of that above Dimbulah but the higher runoff from the former is consistent with the higher average rainfall, the smaller area and the more rugged nature of the country.

Extension of Stream Flow Records.

To cover drought periods that might be critical with regard to the operation of the reservoir, monthly runoffs for years prior to 1938 were estimated by three different methods. A summary of the annual totals, from and including 1895, are shown in Table 76.

Method A—Comparison of Monthly Rainfall and Runoff.

Runoff at Dimbulah in inches for each month of the period 1938 to 1949 inclusive were plotted against the rainfall for the corresponding month and against each point the rainfall for the previous month was written. It was found that correlation between rainfall and runoff was sufficiently good to permit the runoff for each month of previous years to be estimated by comparing similar conditions. Annual runoff by this method is given in Columns 3 and 4 of Table 76.

Method B—From Daily Records of Rainfall.

The depth of runoff in freshes occurring during the period of recorded flows at Dimbulah (1938 to 1950) was correlated with daily rainfalls during storms at the four key stations. Over 100 sets of observations were examined. An estimate of the monthly runoff for the years 1915 to 1937 was then made by comparing storm periods with similar ones for which the runoff was known. Annual totals of runoff are given in Columns 5 and 6 of Table 76.

Statistical methods were also used and, though there were discrepancies in individual years, the average runoff agreed well with the figure obtained by other methods.

Method C—Evapotranspiration Method.

The method devised by Thornthwaite for estimating runoff from rainfall and loss by evapotranspiration was also tried (See Geographical Review Vol. 38, No. 1, January, 1948). The equivalent depth of rainfall stored in the soil was determined by trial over the period of known runoff and a value of 4 inches was adopted. Annual runoff in inches of depth is given in Column 7 of Table 76.

Comparison of Results by the Three Methods.

The total runoff estimated by the three methods for the period 1915-37 is:—

Period.	Runoff in inches.		
	Method A.	Method B.	Method C.
1915–1919 ..	21·90	23·35	32·20
1920–1929 ..	85·30	69·00	92·00
1930–1937 ..	64·55	77·60	74·90
	171·75	169·95	199·10

The values estimated by Method A were adopted although slightly higher than given by Method B, as records of monthly rainfall at the master stations were available from 1895, but daily rainfalls from 1915 only.

RELATION BETWEEN STORAGE CAPACITY AND DRAFT.

Nullinga Reservoir.

The relationship between storage capacity, inflow, normal and average draft, loss by evaporation and seepage, and loss of water over the spillway has been determined by analysis of behaviour curves for 5 storage capacities, ranging from 120,000 to 280,000 acre feet over the 55-year period 1895 to 1949. The results are presented graphically in a series of diagrams, Figs. 12a to 12f.

Fig. 12a shows for the five sizes of reservoirs, control lines which indicate the depletion of storage below full supply level at which normal draft is to be reduced from 30 per cent. above water rights to water rights. The line ABC gives the normal annual draft which can be maintained for 100 per cent. of years for different reservoir capacities without any restrictions.

From A to near the point C, the normal annual draft is proportional to the size of reservoir but further increase of reservoir size does not allow of corresponding increase in draft, and eventually, the line becomes vertical at B indicating a maximum normal draft for 100 per cent. of years of 40,000 acre feet per annum, irrespective of how much the storage capacity is increased above 240,000 acre feet.

At the top of the figure the limit of normal draft is indicated by a straight line. The normal draft, shown at the intersection of a control line with the limit line, can not be maintained throughout any year, i.e., some restriction of supply below normal draft would be required even in the best year of river flow dealt with in the analysis.

Control lines for any size of storage within the limits of the diagram can be interpolated, e.g., 184,000 control line shown in Fig. 12b, and the values of the variables applying to a particular normal draft P′ can be read from the other figures by transferring the point P′ to them.

The frame work of Fig. 12a is used as the basis for Figs. 12b to 12f presenting the values of other variables.

Fig. 12b shows the normal draft which can be obtained for a given percentage of years with a given storage, provided restrictions are applied when the reservoir is depleted by the amount indicated by the intersection of the control line for the storage concerned with the line indicating the percentage of years during which normal draft is to be available. Alternatively either storage capacity or years during which normal draft will be available can be determined if the other two factors are known.

The length of period of reduced supply will vary in different years from a few days to several months.

The term year in these analyses refers to water years or the period 1st April to the 31st March in the following year which generally includes the irrigation and recharge periods.

Fig. 12c indicates the average percentage of time that normal draft can be maintained and the percentage of time during which the supply will be reduced to 100 per cent. water rights and 80 per cent. water rights respectively. It should be noted that shortage during any portion of a year would mean that year was a restricted year, where percentage of years is being considered. Where percentage of time is being considered it would mean that only the proportion of the year affected would be restricted.

Fig. 12d shows that by increasing normal draft for a period of time, that is allowing for the imposition of restrictions to water rights and 80 per cent. water rights as may be required without limit to the frequency of such restrictions, the average annual yield may be considerably improved. (See broken lines in the figure.) The average annual draft is the average draft for all years (normal and restricted). The average draft lines are shown for 5 sizes of storage but may be interpolated for other storages. These lines become tangential to a vertical draft line and the tangent point represents the maximum average draft which can be obtained for the particular reservoir size. The line DE shows the normal annual draft which gives maximum average annual draft for any size of reservoir, by reading the value where DE intersects the control line for the size of the reservoir.

Fig. 12e gives particulars of net evaporation and seepage losses expressed as a percentage of water stored (inflow minus overflow) and of inflow respectively.

Fig. 12f gives particulars of overflow expressed as a percentage of inflow for all conditions of normal draft and reservoir capacity.

Conclusions from the Analysis.

From a hydrologic standpoint the most effective size of reservoir is 208,000 acre feet, which is at Point C on Fig. 12a. It can be seen that for any increase in storage beyond this point, the increase in yield declines rapidly.

However, other factors require consideration in the choice of reservoir size and normal draft. The nature of crops grown and their water requirements, the general economics of the project, and the necessity to avoid frequent curtailment of production due to a large number of periods of restriction, must receive due weight.

Taking these factors into account, the capacity of the Nullinga reservoir has been fixed at 240,000 acre feet and the normal annual draft at 50,000 acre feet. The basis for this selection is given more fully in Part III. (Storages).

Tinaroo Reservoir.

This has been treated similarly to Nullinga storage (see Figs. 13a to 13f).

Provision has been made to maintain the status quo in regard to water available for the Cairns Regional Hydro-Electric Board's power plant at Barron Falls. This necessitates an average release from storage of 41,000 acre feet per annum.

The normal drafts shown in Fig. 13 apply to water for irrigation and are additional to the volume released for hydro-electric use.

Figs. 13b and 13c indicate that the normal draft for 100 per cent. of years or time can be considerably improved by a small percentage of restriction.

Fig. 13d indicates that the average annual yield can be improved by reducing the incidence of normal draft from 100 per cent. of years to 70 per cent. of years, to a maximum for storages up to 540,000 acre feet as shown in Table 56 below.

TABLE 56.

TINAROO FALLS RESERVOIR—NORMAL DRAFT AND AVERAGE ANNUAL YIELD.

Storage capacity acre feet.	Normal draft acre feet per annum 70 per cent. years.	Average annual yield in acre feet.		
		With normal draft for 100 per cent. of years.	With normal draft for 70 per cent. of years.	Per cent. increases.
200,000	123,000	100,000	119,000	19·0
280,000	152,000	125,000	148,000	18·4
320,000	165,000	138,000	158,000	23·8
360,000	177,000	150,000	171,000	14·5
420,000	194,000	168,000	188,000	11·9
480,000	210,000	186,000	201,000	8·1
540,000	218,000	195,000	209,000	7·2

Fig. 13e shows the net loss by evaporation and seepage, expressed as a percentage of stored water after allowing for the rainfall on the submerged area. Stored water is defined as inflow less overflow. It is to be noted that the losses vary between 5 per cent. and 6 per cent. and are less on the smaller reservoir sizes for any particular normal draft.

Fig. 13f illustrates how the efficiency of storage increases with increase in reservoir size.

Conclusions from the Analysis.

High and regular run-off, combined with the adequate storage, permits a large normal draft.

The limit of normal draft which can be taken for 100 per cent. of years is 195,000 acre feet.

The limit of reservoir size up to which the normal annual draft increases proportionately with the capacity is 490,000 acre feet. With this reservoir capacity 188,500 acre feet normal draft may be taken for 100 per cent. of years. For 70 per cent. of years regulation to the normal draft may be increased to 210,000 acre feet per annum.

At the present stage of the investigations the maximum storage at Tinaroo Dam Site has not been definitely established, but it is considered that a capacity of 320,000 acre feet is possible and this figure has been adopted for the purpose of this report. The normal draft has been taken at 165,000 acre feet for 69 per cent. of years (see Fig. 13b). A behaviour diagram has been drawn up for the period 1911-1949 (see Fig. 15).

Combined Operation.

In view of the fact that these storages would water contiguous areas, and that at times it would be advantageous to supply water from either to an area which can be served by both, it is desirable that whenever reduction of draft below normal is necessary, it should be applied simultaneously to both storages and to the areas watered by them.

The following table gives details of storage and draft, values being expressed in acre feet.

TABLE 57.

COMBINED STORAGES, NORMAL AND RESTRICTED DRAFTS.

Storage.	Storage capacity.	Draft.		
		Normal.	100 per cent. water right.	80 per cent. water right.
Tinaroo	320,000	165,000	121,900	101,500
Nullinga	240,000	50,000	38,400	30,700
Combined	560,000	215,000	158,300	132,200

Of the normal draft available from the combined storages, the volumes required annually for the various parts of the project area commandable from the two storages individually and from the two storages combined are as follows:—

Commandable by—

	acre feet.
Nullinga only	30,000
Tinaroo Falls only	78,500
Both Storages	106,500
Total	215,000

Reduction of draft to 100 per cent. water rights and 80 per cent. water rights is to apply when storage capacities have been reduced to the following values, expressed in acre feet.

Storage.	100 Per cent. water rights.	80 Per cent. water rights.
Tinaroo ..	129,000	86,000
Nullinga ..	72,000	48,000
Combined ..	201,000	134,000

Method of Control to Make Restrictions Uniform Over the Irrigated Areas.

It will be noted that Tinaroo storage overflows more frequently than Nullinga, but on three occasions, 1915-16, 1944-45, and 1947-49, under separate control, Tinaroo can supply only 80 per cent. Water Rights, while normal draft is available from Nullinga storage. Any method of control therefore must provide for delivery of water from either storage outside the limits set out for separate control.

There are various ways in which this can be done.

One method which has been tested over the period 1913-50 is set out below:—

(1.) When both storages are full or Tinaroo is full, drawoff from Nullinga at the rate of 60 per cent. of normal, i.e., 30,000 acre feet per annum, and take at the rate of an extra 20,000 from Tinaroo until the combined storage is between 336,000 and 201,000.

(2.) When volume of combined storages is between 336,000 and 201,000 acre feet draw normal supply from each.

(3.) When volume of combined storages is between 201,000 and 134,000 acre feet, draw from each at rate set out for 100 per cent. Water Rights.

(4.) When below 134,000 drawoff from each at 80 per cent. water rights. The above applies generally, but when one reservoir is abnormally lowered in respect of the other, the following extra conditions apply.

(5.) Volume in Nullinga less than 50 per cent. of that in Tinaroo. When combined volume is below 336,000, continue to draw from Nullinga only sufficient to supply the area which Nullinga alone serves, and take the balance from Tinaroo.

(6.) If volume of water in Tinaroo storage is less than that in Nullinga, provided that Tinaroo storage is less than 110,000 acre feet, take equal drafts from each storage until Tinaroo storage recovers to 133⅓ per cent. of Nullinga.

Advantage of Combined Operation.

An increase of 4,000 acre feet per annum is available as a result of combined operation. This is made up from water that is otherwise lost as overflow, as can be seen in Table 58.

In addition to flexibility in control the combined operation, as seen from Fig. 16, although not increasing the area developed extends the period when sales are available, and reduces the periods of restriction necessary as shown for independent operation of the storage on Fig. 15.

TABLE 58.

NULLINGA AND TINAROO FALLS RESERVOIRS, INDIVIDUAL AND COMBINED OPERATION FOR THE PERIOD, 1st APRIL, 1913, TO 31st DECEMBER, 1949. BOTH RESERVOIRS FULL AT COMMENCEMENT OF PERIOD.

—	Individual operation.			Combined operation.		
	Nullinga.	Tinaroo Falls.	Total.	Nullinga.	Tinaroo Falls.	Total.
Storage capacity .. .. ac. ft.	240,000	320,000	560,000	240,000	320,000	560,000
Volume in storage at close of period .. .. ac. ft.	180,000	166,000	346,000	147,000	179,000	326,000
Drawn from storage .. ac. ft.	60,000	154,000	214,000	93,000	141,000	234,000
Inflow during period .. ac. ft.	2,314,000	9,597,000	11,911,000	2,314,000	9,597,000	11,911,000
Total volume passed through reservoir .. ac. ft.	2,374,000	9,751,000	12,125,000	2,407,000	9,738,000	12,145,000
Drawn off for irrigation.. ac. ft.	1,704,000	5,891,000	7,595,000	1,608,000	6,135,000	7,743,000
	71·8%	60·4%	62·6%	66·8%	63·0%	63·7%
Released for Barron Falls power plant .. .. ac. ft.	..	1,538,000	1,538,000	..	1,538,000	1,538,000
	..	15·8%	12·7%	..	15·8%	12·7%
Discharge over spillway .. ac. ft.	306,000	1,906,000	2,212,000	394,000	1,630,000	2,024,000
	12·9%	19·5%	18·2%	16·4%	16·7%	16·7%
Lost by evaporation and seepage .. .. .. ac. ft.	364,000	416,000	780,000	405,000	435,000	840,000
	15·3%	4·3%	6·5%	16·8%	4·5%	6·9%
Total .. .. .. ac. ft.	2,374,000	9,751,000	12,125,000	2,407,000	9,738,000	12,145,000
	100%	100%	100%	100%	100%	100%
Normal annual draft .. ac. ft.	50,000	165,000	215,000	..	..	215,000
Average annual draft .. ac. ft.	46,200	159,600	205,800	43,600	166,200	209,800
Average annual draft as per cent. of normal draft ac. ft.	92·4%	96·7%	95·7%	..	..	97·6%
Increase in average annual draft by combined operation .. .. .. ac. ft.	..	..	..	..	..	4,000
Periods of normal supply—						
Per cent. of years	68	70·3	..	..	..	75·6
Per cent. of time	75	82·9	..	..	..	89·9
Periods of restriction to water rights only—						
Per cent. of years	18·9	18·9	..	..	..	13·5
Per cent. of time	13·0	10·8	..	..	..	8·8
Periods of restriction to 80 per cent. water rights—						
Per cent. of years	16·2	13·5	..	..	..	10·8
Per cent. of time	12·4	5·3	..	..	..	1·4

DIVERSION FROM BARRON RIVER TO WALSH RIVER.

Introduction.

Since the proposed offtake level from Tinaroo storage on the Barron is over 300 feet above the proposed crest level of Nullinga Dam on the Walsh, consideration has been given to the possibility of diverting surplus water from the Barron into the storage at Nullinga.

Basis of Estimation.

Using the estimated daily flows at the Tinaroo Falls Dam site, prepared by the Stanley River Works Board, the flows available for diversion from a 320,000 acre feet storage were investigated for the period 1913 to 1933.

Since it is intended that the whole of the regulated flow available from the Barron—other than that to be released for Barron Falls power plant—be fully utilised by distribution throughout the irrigation system, it was taken that the only flows available for diversion were those that would otherwise pass over the spillway. Two cases were considered—

(*a*) Assuming free overfall above the crest R.L. 2193.

(*b*) Assuming temporary storage of 33,000 acre feet provided by crest gates to R.L. 2197. This temporary storage of surplus flows enables diversion to be continued for a longer period than in the first case, but by lowering the crest gates during periods of high flow, the maximum or flood level in the storage is kept at its original value. Diversion was to be possible when the volume stored exceeds 320,000 acre feet, and to cease when the amount of temporary storage gained was depleted.

Channel Sizes.

Two possible sizes of diversion channel, 350 and 500 cusecs capacity, were investigated for case (*a*) in order to determine the effect of size on the flow diverted. These sizes were selected as covering the range likely to be economically reasonable. Further investigation will be desirable when more detailed information becomes available.

As might be expected, it was found that in different years there was a considerable difference in the ratio of the flows carried by the two sizes of channel, the amount that can be diverted depending on the distribution as well as the magnitude of the surplus flow at the storage. For case (*b*) the 350 cusec channel only was used.

Method of Estimation.

Calculations of behaviour of the 320,000 acre feet storage at Tinaroo Falls were used for the periods during which the reservoir was full.

From the estimated daily inflows at the dam site for these periods, the surplus flows were obtained after making allowance for irrigation and hydro-electric requirements as discussed earlier. Towards the end of each period this surplus flow gradually dropped to zero. The amounts of water that could be diverted by the channels of 350 and 500 cusec capacity during these periods were then found by adding the daily figures in each case.

The above assumption that water could cease to be available for diversion when surplus inflow returned to zero is not correct, since it makes no allowance for the fact that it would be some time before the water level again fell to crest level. Diversion could be continued during this "settling down" period. This error, which is on the safe side, would be more serious in the case of heavy floods of short duration.

It was found that the critical period was from 1913 to 1920 when there was a prolonged drought on the Walsh, and only a small diversion flow available from the Barron. During this period the error referred to above would be very small since the surplus flow dropped slowly from its maximum to zero.

The period 1914 to 1933 only was investigated, as estimated daily flows are not at present available for other years. However, this covers the worst droughts on the Walsh, and enables the effect of diversion to be assessed for the whole period 1913 to 1949, since in the original analysis, no restrictions were required at Nullinga after 1934.

A channel efficiency of 90 per cent. was assumed, as either concrete-lined channel or bench flume would be used over most of the length in order to take advantage of the high velocity possible as a result of the head available. This enables the channel size to be correspondingly reduced.

The quantities available at Nullinga storage in the different cases are tabulated below.

TABLE 59.

POSSIBLE DIVERSIONS FROM BARRON RIVER TO NULLINGA DAM.

Year.	Months.	Volume of water (acre feet) diverted by channel with capacity (cusecs) of—		
		Case (A).		Case (B).
		350	500	350
1914	1–3	12,000	15,500	13,300
	4–6	6,000	6,400	25,900
1921	1–3	3,800	5,400	4,200
	4–6	15,300	19,300	50,000
1922	1–3	12,600	16,000	23,100
	4–6	13,700	15,300	26,300
1923	4–6	1,800	1,800	2,000
1924	4–6	5,100	5,100	5,700
1925	1–3	20,800	29,700	23,100
	4–6	26,600	32,300	62,500
1927	1–3	1,900	2,700	2,100
	4–6	55,700	67,800	63,700
	7–9	..	..	32,000
1928	1–3	6,900	8,000	3,200
	4–6	8,200	8,200	12,300
1929	1–3	17,300	23,400	18,200
	4–6	26,600	32,200	62,500
1930	1–3	32,100	42,900	35,700
	4–6	4,600	4,600	36,400
Totals	..	271,000	336,600	502,400

Effect on Nullinga Storage.

Behaviour calculations were carried out over the period 1913 to 1934 with 240,000 acre feet storage and with the flows carried by the 350 cusec diversion channel, for case (*a*) and case (*b*), added.

These showed that if restrictions are applied at the same storage levels as originally, the annual draft could be raised by 3,000 acre feet to 53,000 acre feet per year in case (*a*) and by 4,000 acre feet to 54,000 acre feet per year in case (*b*), (i.e., with temporary storage above crest level of 33,000 acre feet at Tinaroo Falls Dam). In both cases the severity of restrictions was very much reduced.

If the levels at which restrictions are to be applied are raised so that in each case the degree of restriction is about the same as in the original analysis—i.e., approximately 70 per cent. regulation, then the normal annual drafts can be increased by 7,000 and 12,000 acre feet per year respectively—i.e., with a 350 cusec diversion channel, the temporary storage at Tinaroo Falls Dam enables the draft at Nullinga to be increased by 5,000 acre feet per year.

In the original analysis no restrictions were required at Nullinga after 1934, so that the results for the period 1913-34 obtained in this investigation have been applied to the whole 1913-49 period for determination of percentage regulation.

Alternative Development.

It is indicated above that an increase in yield of 12,000 acre feet per year can be obtained by providing movable crest gates 4 feet high on Tinaroo Falls dam, and diverting surplus water through a 350 cusec channel to Nullinga storage. This same increase could be obtained by building Tinaroo Falls dam to Crest R.L. 2198, for which the normal annual draft would be 177,000 acre feet per year from the 360,000 acre feet storage. However, until more detailed information has been obtained, it is undesirable to fix the final height for Tinaroo Falls Dam.

FLOODS AND SPILLWAY CAPACITY.

Walsh River.

Records of discharge are available for the stream gauging station at Dimbulah, 143·1M from 1938, but large floods did not occur during this period.

The floods of 1911 and 1913 are the largest which have been recorded at the railway bridge at Dimbulah and the peak discharge has been estimated from an extension of the rating curve for the Dimbulah gauging station. The results are set out in Table 60.

TABLE 60.

FLOODS AT DIMBULAH.

Date.	R.L. at rail bridge.	Estimated R.L. at stream gauge.	Height on gauge feet.	Catchment area square miles.	Estimated discharge.		Factor C_m in Formula $C_m \sqrt{A}$.
					Cusecs.	Cusecs per square mile.	
1–4–11	1,481·4	1,500·9	36·3	398	88,000	221	4,400
31–1–13	1,478·8	1,496·3	31·7	398	54,140	146	2,907

Greater floods are possible. In this region, which is subject to severe cyclonic storms, spillway capacity must be provided on a liberal scale, particularly in the case of an earth dam.

At Nullinga Dam (catchment area 124 square miles) it is proposed to provide for a peak inflow at the rate of $7{,}000 \frac{V}{A} = 78{,}000$ cusecs. It has been assumed that the hydrograph of such a flood will be similar in shape to those of lesser floods observed at Dimbulah. Routing this design flood through the reservoir gives a maximum outflow of 50,000 cusecs.

Barron River.

Discharge records are available for Mareeba from 1926 and for Kuranda from August, 1915.

The greatest flood experienced was that of 1911, the level of which at the Kuranda (Hydro) gauging station has been determined, from records by the Railway Department, as R.L. 1072.4 corresponding to height on the gauge of 40 feet 10 inches.

The peak discharge, estimated from an extension of the rating curve was 117,000 cusecs or 158 cusecs per square mile from the catchment area of 740 square miles. The value of the factor C_m in the formula $C_m \frac{V}{A}$ is 4,300.

The peak discharge from the catchment of 332 square miles at Mareeba was 50,000 cusecs or 1,511 cusecs per square mile, giving a value of $C_m = 2{,}740$.

It is proposed that spillway capacity at Tinaroo Falls dam should be sufficient to cope with an inflow from the catchment area of 220 square miles at the rate of $7{,}000 \frac{V}{A} = 104{,}000$ cusecs. Routing such a flood through the reservoir gives a maximum outflow of 43,000 cusecs.

TABLE 61.

MONTHLY RAINFALL, ATHERTON. BARRON RIVER—BASIN II.—4.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1895	1,056	1,495	726	731	297	130	36	39	57	159	116	642	5,484
1896	1,461	712	911	601	30	9	60	50	75	88	52	393	4,442
1897	417	1,200	418	193	102	463	99	32	167	8	72	891	4,662
1898	1,331	1,047	1,979	436	120	214	131	351	15	77	31	140	5,872
1899	893	538	2,326	735	162	72	25	39	177	20	311	80	5,378
1900	1,298	25	215	239	62	13	107	0	81	0	343	437	2,820
1901	900	454	1,195	313	415	20	69	276	113	537	123	142	4,557
1902	62	630	421	168	117	172	224	9	0	101	123	766	2,793
1903	751	403	2,269	1,313	70	109	21	36	0	73	677	1,693	7,415
1904	874	563	1,991	772	169	0	0	64	48	68	125	225	4,899
1905	1,129	566	214	393	322	219	120	90	0	25	385	91	3,554
1906	1,206	709	622	227	252	153	140	134	31	29	630	2,017	6,150
1907	1,433	628	202	110	275	389	0	57	44	20	231	1,358	4,727
1908	1,486	459	1,131	201	158	56	373	12	95	141	83	81	4,276
1909	1,451	241	552	231	179	92	47	124	10	232	626	978	4,763
1910	2,155	1,875	1,159	545	258	317	0	208	51	108	134	1,347	8,157
1911	1,710	1,574	2,011	1,765	56	62	79	0	0	0	20	367	7,644
1912	700	512	698	536	355	335	17	110	48	30	111	182	3,634
1913	3,926	2,106	1,787	179	341	89	54	3	0	48	121	859	3,513
1914	723	727	1,310	301	276	168	39	118	215	150	75	386	4,488
1915	256	294	69	69	60	75	40	0	0	25	168	915	1,961
1916	764	706	376	226	208	51	268	66	205	47	521	1,774	5,212
1917	375	983	659	485	326	51	30	170	43	411	683	981	5,152
1918	1,594	1,030	988	433	226	19	68	139	0	26	182	412	5,114
1919	710	181	599	591	317	128	66	52	85	45	53	113	2,638
1920	1,299	711	102	408	284	32	104	43	24	134	59	871	4,068
1921	744	642	2,625	1,159	253	295	124	92	158	265	0	642	6,999
1922	827	2,372	591	214	129	131	224	13	3	87	29	1,212	5,832
1923	699	394	1,109	298	10	65	52	20	0	47	93	651	3,438
1924	576	610	671	156	263	89	162	93	242	102	679	1,148	4,791
1925	1,054	496	1,530	507	15	322	17	173	27	11	60	755	5,067
1926	1,180	371	562	217	51	157	0	65	281	0	68	983	3,935
1927	1,328	2,142	648	597	84	410	216	12	28	59	20	776	6,320
1928	773	1,811	769	126	103	28	223	108	0	7	554	650	5,152
1929	1,703	2,112	887	552	129	129	52	26	19	22	422	343	6,396
1930	2,399	1,726	310	53	377	114	189	5	71	302	74	450	6,070
1931	1,042	487	287	403	205	205	42	77	31	111	673	939	4,502
1932	1,574	621	646	83	665	83	133	208	10	46	27	962	5,058
1933	841	1,922	253	1,135	205	283	94	271	141	186	514	760	6,605
1934	2,209	1,880	1,436	605	419	274	161	29	233	91	842	69	3,248
1935	504	763	1,656	323	507	57	34	176	0	175	125	121	4,441
1936	835	1,518	1,036	455	347	396	207	4	189	71	37	1,134	6,229
1937	587	1,217	745	163	142	25	344	131	119	21	638	607	4,739
1938	1,081	1,668	146	79	138	140	285	98	95	177	682	120	4,709
1939	1,092	2,956	1,979	387	269	363	91	19	41	126	559	489	8,371
1940	715	1,710	2,036	345	356	372	90	64	34	22	168	89	6,001
1941	1,588	1,032	1,494	1,328	462	35	73	59	29	8	192	333	6,633
1942	164	1,498	187	734	266	239	141	17	186	27	167	1,433	5,059
1943	433	2,251	131	86	116	106	22	0	183	139	79	350	3,896
1944	504	1,352	723	193	11	420	238	112	230	85	60	1,125	5,053
1945	1,522	2,514	2,332	674	405	136	262	72	45	123	174	598	8,856
1946	1,941	1,456	1,061	220	204	64	50	12	0	126	105	202	5,441
1947	442	1,239	1,089	200	332	245	79	499	248	257	547	380	5,557
1948	1,200	365	1,107	319	190	325	161	113	0	8	346	640	4,774
1949	1,475	2,588	1,822	607	265	96	127	201	84	69	582	528	8,444

Rainfall given in points.

100 points = 1 inch.

TABLE 62.

MONTHLY RAINFALL, DIMBULAH, WALSH RIVER—BASIN I.—8.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1933	554	830	199	218	21	24	48	28	29	166	619	728	3,464
1934	756	914	599	197	52	188	12	12	43	7	447	5	3,232
1935	407	336	375	47	297	55	nil	5	nil	29	70	94	1,715
1936	828	529	1,107	142	1	195	7	0	58	10	4	380	3,261
1937	196	775	661	1	25	34	40	0	15	0	497	262	2,506
1938	566	1,322	0	151	5	7	210	6	4	136	338	4	2,749
1939	643	1,139	735	459	0	198	0	0	0	515	264	552	4,505
1940	566	1,156	558	68	17	26	5	1	0	0	169	60	2,626
1941	1,300	650	541	63	34	9	3	1	0	0	125	238	2,964
1942	267	1,355	58	115	10	43	109	12	86	20	132	918	3,125
1943	214	1,297	63	55	0	35	106	70	45	10	50	253	2,198
1944	492	737	275	100	0	56	0	0	0	0	25	405	2,090
1945	517	829	875	166	10	6	3	0	9	33	119	11	2,478
1946	922	830	262	18	0	0	2	0	0	10	63	234	2,341
1947	514	760	435	5	7	19	0	99	174	2	238	159	2,412
1948	518	243	304	84	9	29	25	0	0	71	120	98	1,501
1949	819	1,112	761	135	0	13	0	0	8	87	281	655	3,871
1950	445	239	597	..	..	..	..	..	..	..	..	..	..

Rainfall given in points.
100 points = 1 inch.

TABLE 63.

MONTHLY RAINFALL HERBERTON. BASIN HERBERT RIVER—BASIN II-6.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1886	..	..	..	..	..	..	..	..	..	..	..	..	4,900
1887	1,082	376	1,510	210	210	116	7	32	40	40	481	627	4,731
1888	717	582	579	525	171	84	10	20	103	0	132	461	3,284
1889	112	1,136	491	435	227	45	202	37	0	68	795	991	4,539
1890	1,146	1,393	587	414	142	67	79	79	160	133	313	219	4,732
1891	615	2,287	329	619	252	72	33	41	36	90	151	584	5,109
1892	1,973	497	684	234	181	97	29	15	1	198	274	557	4,740
1893	480	987	181	0	76	35	19	382	8	360	277	400	3,205
1894	1,763	952	994	2,461	80	340	51	38	45	171	354	510	7,759
1895	1,347	1,070	472	481	185	55	28	11	22	101	121	537	4,430
1896	1,754	712	911	601	30	9	60	21	13	31	29	426	4,597
1897	406	768	687	85	291	286	48	10	64	41	9	752	3,447
1898	1,029	1,074	1,676	185	72	92	121	215	45	11	3	120	4,613
1899	819	493	2,132	674	149	66	23	36	162	18	285	73	4,930
1900	1,190	23	197	219	57	12	98	0	74	0	314	401	2,585
1901	825	416	1,095	287	380	18	64	253	104	492	113	130	4,177
1902	57	577	386	154	107	158	205	8	0	93	113	702	2,560
1903	688	369	2,080	1,204	64	100	19	33	0	57	621	1,552	6,797
1904	801	516	1,825	708	155	0	0	59	44	62	115	206	4,491
1905	739	337	75	241	267	117	5	89	0	21	169	51	2,111
1906	1,520	373	467	125	138	104	59	55	38	30	516	1,082	4,507
1907	1,056	1,177	205	90	157	271	0	11	12	17	341	957	4,294
1908	973	502	891	136	38	0	236	0	31	130	61	82	3,100
1909	1,241	288	350	70	81	82	20	75	50	230	450	511	3,388
1910	1,664	1,221	1,240	350	185	170	0	88	58	43	493	972	6,484
1911	1,143	1,316	1,535	1,438	58	36	40	5	0	9	62	536	6,178
1912	529	282	417	140	230	236	39	129	53	78	182	300	2,615
1913	2,643	1,257	1,052	359	363	73	45	0	5	66	214	549	6,626
1914	641	668	1,411	354	159	213	37	105	150	95	64	367	4,264
1915	90	202	58	32	86	66	22	0	4	19	50	856	1,485
1916	550	1,048	367	276	169	30	303	79	141	85	239	1,385	4,672
1917	678	791	998	360	396	30	22	144	2	119	387	821	4,748
1918	1,479	1,002	739	329	107	5	102	117	8	20	377	381	4,666
1919	627	281	271	261	301	81	49	48	94	6	64	77	2,160
1920	1,184	512	187	263	462	94	88	141	23	133	85	906	4,078
1921	522	307	2,113	1,198	292	268	240	61	97	303	10	727	6,138
1922	686	1,777	595	189	116	94	217	12	12	81	116	616	4,511
1923	535	374	598	195	50	96	101	25	7	21	85	443	2,530
1924	638	567	694	117	113	54	119	109	144	70	1,002	366	3,993
1925	910	891	897	382	3	202	26	70	99	6	161	554	4,201
1926	1,205	227	459	134	0	36	26	31	94	0	217	1,085	3,514
1927	1,339	1,030	627	281	58	345	185	7	17	36	130	494	4,599
1928	531	1,360	674	63	54	24	258	12	0	4	515	658	4,153
1929	1,440	1,463	1,045	99	81	87	29	6	28	58	505	500	5,350
1930	1,746	959	377	129	248	57	116	5	36	309	167	800	4,949
1931	406	369	138	215	154	166	50	61	26	57	346	789	2,777
1932	1,139	311	410	155	497	77	92	132	12	110	7	717	3,659
1933	655	1,327	128	698	347	173	112	122	102	186	601	443	4,894
1934	1,866	1,907	1,280	439	266	273	143	37	246	58	626	194	7,335
1935	634	464	1,124	200	440	86	17	75	3	146	180	258	3,617
1936	720	1,043	1,116	267	160	268	116	0	85	87	36	707	4,605
1937	432	964	638	35	127	7	166	42	60	14	381	472	3,338
1938	775	1,528	65	47	44	75	237	63	35	110	512	96	3,587
1939	585	1,795	2,165	278	80	354	32	16	0	90	435	411	6,241
1940	710	2,052	1,370	228	235	175	63	30	20	8	412	53	5,356
1941	1,124	774	1,211	672	211	22	53	118	15	0	131	400	4,731
1942	142	1,587	145	422	152	157	154	2	137	30	247	1,327	4,502
1943	1,112	2,032	86	38	64	78	5	0	93	34	208	241	3,991
1944	347	1,044	394	210	5	255	179	46	115	59	48	767	3,470
1945	1,174	1,710	1,635	281	208	74	161	33	49	108	202	341	5,974
1946	1,393	1,137	858	49	109	27	54	15	0	93	66	250	4,051
1947	237	1,061	483	87	106	142	44	371	148	81	585	400	3,745
1948	935	424	790	186	152	194	114	104	0	6	230	568	3,703
1949	1,206	1,555	1,488	243	116	47	48	137	44	108	370	376	5,738

Rainfall given in points.
100 points = 1 inch.

TABLE 64.

MONTHLY RAINFALL, IRVINEBANK, WALSH RIVER—BASIN I.—8.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1892	938	175	398	141	2	0	179	0	11	364	436	682	3,326
1893	590	1,096	101	47	7	0	0	305	0	186	258	584	3,174
1894	1,707	824	483	1,218	55	129	64	13	72	393	430	323	5,711
1895	1,755	992	146	342	21	9	3	0	2	24	53	616	3,963
1896	1,228	628	682	76	0	1	45	7	0	20	37	296	3,020
1897	621	819	350	4	190	51	3	1	12	166	16	551	2,784
1898	1,161	1,253	1,067	39	0	9	58	51	33	40	0	274	3,985
1899	1,341	468	1,836	570	4	21	37	49	8	9	18	0	4,461
1900	783	2	138	456	3	3	36	0	73	0	125	74	1,693
1901	794	354	1,476	292	154	29	2	219	63	248	9	5	3,645
1902	184	686	91	29	27	15	44	0	0	6	4	1,024	2,110
1903	644	848	1,596	893	23	39	0	6	0	50	409	1,589	6,097
1904	805	569	877	369	0	0	0	0	0	142	139	326	3,227
1905	1,472	627	158	138	176	27	26	7	0	0	202	42	2,875
1906	1,239	335	504	33	0	0	5	0	38	14	482	947	3,597
1907	627	452	342	33	48	152	0	0	0	22	338	1,006	3,020
1908	544	371	629	39	80	0	163	7	45	274	108	125	2,385
1909	933	520	714	89	151	184	39	11	42	281	349	731	4,044
1910	1,879	966	847	122	45	79	2	23	139	90	324	1,167	5,681
1911	751	1,175	868	1,053	17	3	7	0	0	4	263	781	4,922
1912	804	120	321	49	56	188	3	44	30	64	332	151	2,162
1913	2,038	1,526	830	317	299	56	0	0	30	64	113	501	5,774
1914	410	245	1,264	262	37	177	9	54	40	11	42	201	2,752
1915	171	74	61	0	158	10	13	0	2	9	38	644	1,180
1916	598	1,253	194	197	24	20	135	14	5	378	363	1,025	4,206
1917	824	992	869	190	199	20	2	28	10	115	170	565	3,984
1918	1,982	838	806	84	3	0	8	7	0	80	231	504	4,543
1919	440	191	366	41	88	11	16	18	7	2	7	194	1,381
1920	1,460	526	473	34	280	22	26	65	127	13	25	727	3,778
1921	294	262	1,233	357	67	102	162	0	36	198	70	1,307	4,088
1922	896	1,995	225	19	6	112	144	0	0	12	58	668	4,035
1923	831	127	374	94	39	43	0	35	0	0	9	382	1,934
1924	361	950	539	25	2	31	0	67	91	132	377	380	2,964
1925	792	478	882	88	0	80	0	0	45	0	75	575	3,015
1926	867	142	703	1	50	0	0	0	0	0	141	925	2,829
1927	147	1,224	645	122	43	347	76	0	2	0	161	283	4,320
1928	812	973	245	44	0	0	9	0	31	13	460	722	3,129
1929	894	1,728	690	247	0	27	0	0	0	5	347	138	4,076
1930	1,868	1,745	81	117	190	3	29	0	0	250	154	311	3,748
1931	341	261	10	100	43	5	0	0	0	3	294	462	1,519
1932	911	489	173	64	126	35	0	0	0	0	0	741	2,543
1933	378	1,129	120	285	73	4	72	122	70	171	511	790	3,728
1934	1,228	968	620	175	138	201	0	42	0	33	509	130	4,044
1935	166	494	312	0	270	0	0	0	0	95	0	233	1,571
1936	633	567	1,295	98	0	26	0	0	0	81	51	692	3,543
1937	357	354	663	0	0	25	58	0	0	0	327	610	2,394
1938	1,047	1,182	54	113	0	0	185	0	5	31	374	54	3,045
1939	441	1,307	806	333	0	199	0	0	0	208	356	668	4,318
1940	751	1,724	604	58	37	35	0	0	0	0	476	0	3,685
1941	1,108	472	871	147	90	22	11	19	3	0	234	229	3,206
1942	41	1,421	61	68	10	42	117	0	56	17	362	1,065	3,260
1943	398	1,529	70	0	0	47	0	0	66	88	119	493	2,810
1944	498	913	498	71	0	63	67	0	10	22	136	366	2,644
1945	688	1,322	1,020	78	26	0	11	0	0	46	13	77	3,281
1946	1,387	946	645	0	0	0	0	0	0	33	134	400	3,545
1947	475	1,176	461	0	6	86	0	65	107	65	317	259	3,017
1948	414	227	383	0	0	21	6	5	0	62	165	180	1,463
1949	1,086	1,332	1,282	73	0	0	0	21	29	97	421	514	4,855

Rainfall given in points.
100 points = 1 inch.

TABLE 65.

MONTHLY RAINFALL MAREEBA, BARRON RIVER—BASIN II-4.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1895	1,277	1,458	120	680	0	15	0	0	0	0	25	172	3,747
1896	642	942	775	580	0	0	0	40	0	5	23	251	3,258
1897	347	250	414	26	372	25	0	0	0	205	77	564	2,280
1898	1,305	1,713	1,020	130	0	190	5	38	30	0	21	43	4,975
1899	1,180	383	2,690	214	0	35	0	10	11	8	223	6	4,805
1900	1,317	0	91	211	14	19	56	30	38	0	232	231	2,239
1901	944	652	496	175	23	4	75	42	55	190	80	142	2,878
1902	184	687	91	29	27	15	44	0	0	6	4	1,023	2,110
1903	919	874	1,920	1,094	0	15	0	0	0	159	333	1,071	6,385
1904	745	473	1,169	583	25	0	0	0	76	0	5	233	3,309
1905	1,345	432	373	87	16	0	6	0	1	6	116	0	2,382
1906	627	658	1,217	54	32	7	26	0	0	0	488	553	3,662
1907	851	695	151	0	123	151	0	0	0	0	367	725	3,063
1908	1,241	422	758	157	68	0	179	12	52	41	0	39	2,969
1909	1,184	259	466	41	8	52	11	12	84	132	430	805	3,484
1910	1,155	1,098	910	370	78	55	0	0	106	392	171	1,238	5,573
1911	1,150	1,630	2,224	2,218	9	11	0	0	0	8	0	89	7,339
1912	454	225	688	70	9	140	0	0	0	147	45	159	1,937
1913	2,237	1,286	870	212	209	44	3	0	0	24	16	393	5,294
1914	1,129	900	767	159	22	94	9	13	13	0	0	398	3,504
1915	442	152	148	20	10	17	7	0	0	0	73	501	1,370
1916	987	304	392	249	67	9	45	5	25	52	114	1,351	3,600
1917	440	773	802	198	225	15	0	47	0	97	296	583	3,476
1918	1,158	934	322	80	19	0	72	14	0	42	169	398	3,208
1919	413	175	510	100	81	35	21	9	10	1	22	139	1,516
1920	681	783	198	183	173	12	99	132	3	103	5	246	2,618

TABLE 65—*continued.*

MONTHLY RAINFALL MAREEBA, BARRON RIVER—BASIN II-4.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1921	563	425	1,516	618	83	106	54	11	46	208	28	864	4,522
1922	1,084	1,157	389	50	0	103	202	0	0	35	35	402	3,457
1923	432	323	722	101	0	89	8	26	0	0	17	399	2,117
1924	329	402	525	116	47	44	11	120	36	55	324	353	2,362
1925	645	1,070	996	147	0	74	5	7	18	3	33	461	3,459
1926	1,615	134	260	65	36	104	3	2	79	0	3	347	2,549
1927	851	1,448	290	293	18	236	95	4	0	0	8	510	3,753
1928	537	1,208	554	96	4	0	5	0	0	0	182	748	3,334
1929	1,544	1,786	614	479	8	71	0	0	2	0	114	177	4,795
1930	1,885	915	361	9	136	36	51	0	0	220	65	174	3,852
1931	561	275	87	149	42	44	5	0	0	25	500	764	2,452
1932	1,359	256	429	133	208	0	5	14	9	0	0	705	3,118
1933	558	1,150	231	200	101	72	30	199	77	166	692	840	4,316
1934	1,350	1,413	1,451	267	62	101	29	4	38	15	239	28	4,997
1935	373	502	855	49	271	5	5	3	1	22	82	49	2,217
1936	564	1,219	1,259	116	16	374	8	0	64	92	15	1,209	4,936
1937	366	667	691	57	36	0	115	11	17	0	260	520	2,740
1938	1,046	1,332	127	0	11	14	164	11	0	194	331	9	3,239
1939	745	1,527	1,429	251	17	324	0	0	0	180	165	220	4,858
1940	947	1,633	1,421	112	34	77	9	16	0	9	46	0	4,314
1941	1,036	997	791	290	84	2	7	13	0	0	140	299	3,659
1942	16	1,072	80	227	29	62	48	35	4	3	91	1,175	2,842
1943	480	1,550	128	76	2	15	0	0	72	139	85	289	2,836
1944	380	1,441	395	116	9	113	75	10	29	15	5	636	3,224
1945	882	1,617	1,180	276	50	24	24	0	0	16	60	187	4,316
1946	952	866	248	18	1	0	0	0	0	40	90	75	2,290
1947	166	1,172	514	27	13	7	8	173	84	0	300	314	2,778
1948	731	92	794	87	60	32	66	6	0	0	86	207	2,161
1949	768	2,156	769	390	38	20	7	35	15	74	240	273	4,785

Rainfall given in points.
100 points = 1 inch.

TABLE 66.

MONTHLY RAINFALL WATSONVILLE, WALSH RIVER—BASIN I-8.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1938	800	1,743	50	126	12	14	216	0	9	41	325	38	3,374
1939	756	1,598	1,331	170	25	236	13	308	5	130	492	812	5,876
1940	347	2,040	930	99	170	266	26	5	0	0	197	163	4,243
1941	1,232	328	1,015	330	115	15	30	61	3	14	517	145	3,805
1942	169	1,463	93	389	52	105	144	2	77	9	319	1,515	4,337
1943	733	1,894	84	0	17	64	0	0	59	32	260	399	3,542
1944	555	1,245	379	106	0	96	108	0	42	34	45	585	3,195
1945	1,037	1,518	1,365	141	50	0	50	0	0	70	95	194	4,520
1946	1,306	1,259	908	25	0	0	0	0	0	90	124	359	4,071
1947	331	898	281	32	35	60	0	212	123	0	833	159	3,064
1948	760	145	806	135	0	69	0	45	0	34	181	165	2,340

Rainfall given in points.
100 points = 1 inch.

TABLE 67.

RAINFALL ON NULLINGA DAM CATCHMENT—BASED ON HERBERTON-ATHERTON KEY STATIONS BY 0·873.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1895	1,052	1,122	524	530	211	81	28	22	34	114	104	516	4,388
1896	1,406	623	797	526	26	8	53	31	38	53	35	358	3,954
1897	360	1,123	482	122	172	327	65	18	102	21	36	719	3,547
1898	1,032	927	1,601	272	71	134	110	248	26	38	15	114	4,588
1899	749	451	1,950	617	136	60	21	33	148	17	261	67	4,510
1900	1,088	21	180	200	52	11	90	0	67	0	288	367	2,364
1901	754	380	1,002	262	348	17	58	232	94	451	103	119	3,820
1902	52	528	353	141	98	144	188	7	0	85	103	642	2,341
1903	629	338	1,903	1,101	59	92	17	30	0	61	568	1,420	6,218
1904	733	472	1,670	647	142	0	0	53	40	57	105	189	4,108
1905	817	395	127	277	257	147	55	78	0	20	243	62	2,478
1906	1,193	473	476	154	171	113	87	83	30	26	501	1,355	4,662
1907	1,088	790	178	88	189	289	0	21	25	17	250	1,012	3,947
1908	1,075	421	885	147	86	24	267	5	64	118	63	72	3,227
1909	1,178	205	394	132	114	76	30	87	26	202	471	651	3,566
1910	1,671	1,355	1,049	392	194	213	0	129	48	66	274	1,014	6,405
1911	1,247	1,264	1,551	1,402	50	43	52	3	0	4	36	395	6,047
1912	537	350	489	296	255	250	24	104	44	47	128	211	2,735
1913	2,874	1,472	1,242	235	308	71	44	1	3	50	146	616	7,062
1914	597	610	1,190	286	191	166	34	97	159	108	61	330	3,829
1915	151	217	56	40	64	62	27	0	2	19	95	773	1,506
1916	574	766	325	219	165	36	250	64	151	58	332	1,379	4,319
1917	460	774	724	368	315	36	23	137	22	231	445	737	4,322
1918	1,342	887	754	333	146	10	74	112	3	20	244	347	4,272
1919	584	202	380	372	270	92	51	44	78	23	52	33	2,231
1920	1,084	534	127	293	326	55	84	80	19	17	63	776	3,458

TABLE 67—*continued.*

RAINFALL ON NULLINGA DAM CATCHMENT—BASED ON HERBERTON-ATHERTON KEY STATIONS BY 0·873.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1921	553	415	2,068	1,029	238	246	159	67	2	248	4	598	5,627
1922	661	1,811	518	176	107	99	193	11	7	73	64	798	4,518
1923	539	335	746	216	26	71	67	20	3	30	78	478	2,609
1924	530	514	596	120	164	63	123	88	168	75	734	661	3,836
1925	857	650	1,060	388	8	229	19	107	55	8	97	572	4,050
1926	1,041	261	446	154	23	85	11	42	164	0	125	903	3,255
1927	1,165	1,385	557	383	62	330	175	9	20	64	65	554	4,769
1928	570	1,385	630	83	69	23	210	52	0	5	467	571	4,065
1929	1,372	1,561	843	285	92	94	36	14	21	35	405	368	5,126
1930	1,810	1,172	300	79	273	75	134	4	47	267	106	546	4,813
1931	632	374	186	270	157	162	40	60	25	73	445	754	3,178
1932	1,185	407	461	104	507	70	99	148	10	68	15	733	3,807
1933	653	1,419	167	801	241	199	90	172	107	162	487	526	5,024
1934	1,779	1,653	1,106	456	299	239	133	29	230	65	641	15	6,705
1935	497	536	1,213	229	414	63	23	110	2	141	134	166	3,528
1936	679	118	939	315	222	377	141	2	120	69	32	804	3,818
1937	445	952	604	86	118	14	223	76	79	16	445	471	3,529
1938	1,247	1,395	93	55	79	94	228	71	57	126	521	94	4,060
1939	732	2,074	1,809	291	153	313	54	16	18	94	434	393	6,381
1940	622	1,642	1,487	251	258	239	67	41	24	13	253	62	4,959
1941	1,184	783	1,181	873	294	25	55	78	19	3	141	320	4,956
1942	134	1,347	145	505	182	173	129	9	141	25	181	1,205	4,176
1943	675	1,870	95	54	79	80	12	0	120	76	126	258	3,445
1944	372	1,046	488	176	7	295	182	69	151	63	47	826	3,722
1945	1,177	1,844	1,731	417	268	92	185	46	41	101	164	410	6,476
1946	1,455	1,132	838	118	137	40	45	12	0	96	75	197	4,145
1947	297	1,004	686	126	191	169	54	380	173	148	494	340	4,062
1948	932	345	828	221	149	227	120	95	0	6	251	527	3,701
1949	1,171	1,809	1,445	371	167	63	77	148	56	78	416	395	6,196
1950	..	..	..	..	..	..	..	..	..	..	..	..	..

Rainfall given in points.
100 points = 1 inch.

TABLE 68.

RAINFALL ON NULLINGA DAM CATCHMENT—BASED ON MAREEBA-IRVINEBANK KEY STATIONS BY 1·310.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1895	1,906	1,603	174	669	13	16	3	0	1	16	51	516	5,048
1896	1,225	1,028	954	430	0	1	29	31	0	16	39	359	4,112
1897	634	701	500	20	368	50	1	1	8	241	62	730	3,316
1898	1,615	1,943	1,366	111	0	131	41	59	41	52	14	207	5,580
1899	1,651	558	2,965	514	3	37	25	38	13	10	159	4	5,977
1900	1,376	1	149	438	10	14	60	20	73	0	233	200	2,574
1901	1,138	659	1,292	305	117	21	51	170	77	287	59	96	4,272
1902	246	916	121	39	35	21	59	0	0	8	5	1,365	2,815
1903	1,024	1,128	2,303	1,301	16	35	0	4	0	136	486	1,742	8,175
1904	1,015	683	1,340	624	16	0	0	0	50	93	94	367	4,282
1905	1,846	694	349	148	126	18	21	5	1	4	209	27	3,448
1906	1,224	669	1,052	54	20	5	20	0	25	9	634	982	4,694
1907	968	752	323	22	113	202	0	0	0	14	462	1,135	3,991
1908	1,175	528	913	129	97	0	258	13	65	208	71	108	3,560
1909	1,392	513	776	86	105	155	32	16	83	272	514	1,012	4,956
1910	2,000	1,360	1,152	323	81	88	1	16	161	316	325	1,580	7,403
1911	1,247	1,840	2,023	2,142	17	9	5	0	0	8	173	537	8,001
1912	824	228	662	668	43	215	3	4	20	139	243	216	3,270
1913	2,799	1,842	1,114	347	332	66	1	0	20	58	85	586	7,250
1914	1,007	751	1,330	276	38	178	12	43	35	7	23	393	4,098
1915	402	148	138	13	110	18	13	0	1	7	73	751	1,674
1916	1,039	1,020	384	292	60	20	118	13	20	282	313	1,556	5,117
1917	828	1,157	1,095	254	278	24	1	50	7	139	305	752	4,890
1918	2,057	1,161	739	107	14	0	59	14	0	80	262	591	5,084
1919	559	240	574	94	111	30	25	18	12	3	20	219	1,905
1920	1,403	858	440	143	297	22	83	130	85	76	20	638	4,195
1921	562	451	1,801	639	98	136	141	8	54	266	64	1,423	5,643
1922	1,297	2,065	402	46	4	76	227	0	0	31	62	701	4,911
1923	828	295	718	128	26	86	5	42	0	0	17	512	2,657
1924	452	886	697	94	33	50	8	123	84	123	460	486	3,496
1925	942	1,014	1,230	155	0	101	4	5	42	3	71	679	4,246
1926	1,626	181	566	43	56	68	3	1	52	0	94	833	3,523
1927	1,486	1,750	613	272	41	383	113	3	1	0	111	520	5,293
1928	884	1,429	524	92	3	0	9	0	21	9	421	963	4,355
1929	1,597	2,302	854	476	5	64	0	0	1	4	303	207	5,813
1930	2,459	1,742	290	83	214	26	52	0	0	308	157	318	5,649
1931	591	351	64	164	56	33	4	0	10	18	520	803	2,604
1932	1,487	489	394	130	219	24	4	9	7	0	0	947	3,710
1933	613	493	231	318	114	50	67	211	97	221	841	1,068	5,324
1934	1,689	1,560	1,357	290	131	198	20	30	25	31	490	103	5,924
1935	354	652	765	33	355	4	4	3	1	77	54	185	2,487
1936	785	1,170	1,673	140	10	328	5	0	42	114	43	1,246	5,556
1937	481	669	887	38	24	17	114	8	12	0	385	740	3,375
1938	1,372	1,581	119	75	8	9	229	8	4	148	462	42	4,057
1939	777	1,856	1,465	383	12	343	0	0	0	254	342	582	6,014
1940	1,119	1,544	1,327	111	47	73	7	10	0	7	342	0	4,587
1941	1,404	963	1,089	287	114	16	12	21	3	0	245	346	4,500
1942	38	1,634	93	194	26	68	109	24	39	13	297	1,467	4,002
1943	575	2,017	130	50	1	41	0	0	90	149	134	512	3,699
1944	575	1,542	586	123	7	115	93	7	26	25	93	656	3,848
1945	1,028	1,926	1,441	232	50	16	24	0	0	41	48	173	4,979
1946	1,533	1,187	586	12	1	0	0	0	0	48	147	312	3,826
1947	421	1,538	639	18	13	62	5	156	126	43	405	376	3,802
1948	751	210	772	58	39	35	47	8	0	41	165	254	2,380
1949	1,214	2,285	1,344	204	25	13	5	37	29	113	434	516	6,219

Rainfall given in points.
100 points = 1 inch.

TABLE 69.

ANALYSIS OF RAINFALL RECORDS USED IN DETERMINATION OF ISOHYETS OVER CATCHMENTS OF THE BARRON RIVER AND THE WALSH RIVER ABOVE DIMBULAH.

Station.	Period of record.	Length of record.	Mean Annual rainfall.	35-year mean in relation to master stations. (Inches).		Accepted 35-year mean.	Maximum annual rainfall over period of record.		Minimum annual rainfall over period of record.		Maximum monthly rainfall over period of record.	
		Years.	Inches.	H.A.	M.I.	Inches.	Inches.	Year.	Inches.	Year.	Inches.	Date.
1 Reichardt	1939–1949	11	26·81	24·07	25·90	24·99	34·83	1939	14·56	1947	17·28	Feb., 1943
2 Petford	1921–1949	29	32·34	30·23	31·08	30·66	47·38	1941	15·11	1935	20·63	Jan., 1941
3 Mount Mulligan	1923–1924	2	23·58	..	..	..	..	..	..	..	..	..
	1927–1931	5	32·67	..	29·25	29·25	40·30	1929	17·84	1923	19·77	Jan., 1930
	1947–1949	3	26·48	..	..	..	..	..	..	..	..	..
4 Kimalo	1941–1946	6	28·96	26·12	28·70	27·41	37·00	1942	16·10	1948	18·00	Feb., 1943
	1948–1949	2	25·93	..	..	..	..	..	..	..	..	..
5 Dimbulah	1932–1949	18	27·20	25·10	27·72	26·41	45·05	1939	15·01	1948	13·55	Feb., 1942
6 Selby	1933–1949	17	27·65	25·25	26·62	25·94	40·96	1949	13·93	1948	17·01	Feb., 1943
7 Southedge	1942–1949	8	33·26	31·59	34·56	33·08	52·18	1949	21·70	1948	22·84	Feb., 1949
8 Paddy's Green	1939–1946	8	35·93	32·03	33·97	33·00	50·55	1939	26·35	1943	18·03	Feb., 1945
9 Thornborough	1881–1888	8	29·71	35·26	32·77	34·02	92·36	1903	12·38	1919	37·22	Jan., 1890
	1890–1930	41	35·13	..	..	..	..	..	..	..	..	..
10 Watsonville	1938–1948	11	38·52	..	40·00	40·00	58·76	1939	23·40	1948	20·40	Feb., 1940
11 Barrine	1918–1919	2	34·66	56·50	..	56·50	90·82	1934	22·76	1919	37·14	Jan., 1930
	1924–1949	26	59·25	..	..	..	..	..	..	..	..	..
12 Carbeen	1933–1935	3	46·15	33·30	35·70	54·50	58·48	1939	19·80	1946	20·84	Feb., 1939
	1937–1949	13	34·24	..	..	..	..	..	..	..	..	..
13 Chewko	1932–1943	12	32·19	29·98	30·59	30·29	45·15	1934	19·75	1935	15·20	Feb., 1943
14 Clohesy River	1935–1948	14	42·05	..	43·44	43·44	64·04	1945	25·77	1937	25·81	Feb., 1939
15 Yungaburra	1926–1949	24	54·45	51·37	51·38	51·37	82·23	1945	34·11	1937	25·79	Mar., 1945
16 Upper Barron Reserve	1923–1949	27	56·92	54·40	..	54·40	85·67	1945	36·86	1923	25·43	Mar., 1940
17 Topgate	1934–1936	3	94·42	80·23	..	80·23	124·22	1934	61·95	1942	29·75	Feb., 1934
	1942–	1	..	..	..	..	..	..	..	..	..	..
18 Malanda	1916–1949	34	66·63	62·16	65·83	62·16	107·01	1921	44·79	1943	29·52	Mar., 1940
19 Gadgarra	1922–1949	28	80·20	76·91	..	76·91	142·90	1945	52·45	1937	50·27	Mar., 1945
20 Danbulla	1922–1929	8	..	..	..	75·83	..	..	..	..	..	..
	1932–1949	18	..	..	..	..	..	..	..	..	..	..
21 Kairi	1914–1934	21	47·99	50·29	48·16	50·29	77·68	1921	18·06	1915	31·17	Mar., 1921
22 Peeramon	1928–1949	22	66·70	62·31	..	62·31	104·67	1945	45·17	1946	38·83	Mar., 1945
23 Severin Forest	1927–1945	19	67·08	51·66	..	51·66	104·96	1945	44·76	1943	37·54	Mar., 1945
24 Kuranda	1899–1902	4	72·73	..	..	..	..	..	..	..	..	..
	1904–1944	41	81·78	77·35	..	77·35	192·85	1911	29·50	1915	72·47	Apr., 1911
25 Studmore	1934–1949	16	36·98	38·89	36·02	34·96	53·58	1936	21·70	1948	22·84	Feb., 1949
26 Strathbouin	1934–1935	2	34·30	31·93	34·26	34·26	49·87	1939	24·12	1935	17·58	Feb., 1939
	1938–1945	8	36·40	..	..	..	..	..	..	..	..	..
27 Spring Creek–Tolga	1929–1940	12	49·78	45·90	46·24	46·07	71·69	1934	35·26	1935	26·47	Jan., 1930

TABLE 70.

DISCHARGE OF WALSH RIVER AT DIMBULAH.

BASIN 1–8–4–9. A.M.T.M. 142·9. CATCHMENT AREA 398 SQ. MILES.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.	—
1937 ..	No record		..	..	..	0	0	0	0	0	1,797	4,251	..	..
1938 ..	7,924	150,548	6,363	1,083	178	11	402	3	0	0	45	742	167,299	..
1939 ..	7,156	168,855	148,481	19,194	3,714	3,149	1,174	361	42	0	0	2,133	354,259	..
1940 ..	4,645	108,700	142,913	14,293	2,856	3,004	1,588	1,027	414	44	0	0	279,484	..
1941 ..	2,385	59,705	85,144	20,059	4,101	2,146	1,003	645	229	0	287	176	175,880	..
1942 ..	33	90,860	8,885	1,386	897	555	779	83	0	0	0	20,558	124,036	..
1943 ..	9,027	165,162	34,812	974	154	109	53	2	0	0	0	51	210,344	..
1944 ..	9,890	28,741	23,661	2,668	22	0	66	3	0	0	0	674	65,725	..
1945 ..	14,386	300,591	126,404	8,295	2,826	1,434	1,150	563	258	22	0	0	455,929	..
1946 ..	35,221	103,219	58,593	597	34	12	0	0	0	0	0	136	197,812	..
1947 ..	2,744	23,901	18,522	6,782	398	292	46	2,027	26	0	1,775	582	57,095	..
1948 ..	3,273	5,483	7,899	1,184	176	387	1,451	2	0	0	0	0	19,855	..
1949 ..	15,142	175,135	86,901	26,632	4,449	2,603	2,134	1,323	13	0	2,146	3,568	320,046	..
Totals ..	111,826	380,900	748,578	103,147	19,805	13,702	9,846	6,039	982	66	4,253	28,620	2,427,764	..
Means ..	9,319	115,075	62,381	8,596	1,650	1,142	821	503	82	6	354	2,385	202,314	For 12 year period
Runoff in.	0·44	5·42	2·94	0·40	0·08	0·05	0·04	0·02	0·004	0·0003	0·02	0·11	9·53	..
Av. Ac. ft./sq. ml.	23·41	289·13	156·74	21·60	4·15	2·87	2·06	1·26	·21	·02	·89	5·99	508·33	..
1950 ..	25,768	12,923	79,171	22,622	1,495	4,159	..	..	..	..	..	..	..	..

Discharges given in acre feet.

TABLE 71.

DISCHARGE OF WALSH RIVER AT TABACUM, G.S. 370 AND 422.

BASIN 1–8–4–9. A.M.T.M. 158–6. CATCHMENT AREA 169 SQ. MILES.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1948	..	..	..	..	..	..	..	172	40	N.F.	N.F.	N.F.	212
1949	12,858	81,030	78,427	17,990	3,226	1,267	818	718	507	44	1,400	2,400	200,412
1950	16,000	8,000	52,888	19,958	2,916	5,562	1,893	365	183	239	..	..	..

Discharges given in acre feet.

TABLE 72.

DISCHARGE OF BARRON RIVER AT KURANDA.

BASIN II–4–1. A.M.T.M. 14·2. CATCHMENT AREA 736 SQUARE MILES.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1915	No	record	..	..	..	..	..	4,550	2,850	1,845	1,964	9,842	21,051
1916	87,588	49,575	23,558	4,671	13,658	8,101	8,339	8,648	8,920	6,625	8,895	186,751	415,329
1917	154,929	86,596	115,538	36,442	31,752	19,968	14,355	11,151	7,746	7,746	21,019	47,653	554,895
1918	150,725	190,467	146,788	208,775	65,417	28,786	24,423	18,778	14,418	8,608	6,218	16,802	859,175
1919	40,905	13,008	46,132	51,636	30,548	15,052	20,747	27,995	25,805	17,379	9,396	5,143	303,728
1920	34,179	252,702	19,781	85,886	75,368	19,505	10,344	16,741	11,526	8,235	8,747	21,463	564,477
1921	33,307	52,475	653,916	598,293	71,651	61,335	39,166	24,791	29,562	21,287	13,918	36,403	1,636,104
1922	102,809	327,814	211,357	51,529	43,018	24,966	28,144	16,773	13,414	10,071	7,602	13,235	850,732
1923	16,624	12,663	124,723	42,202	14,987	14,798	10,457	8,882	6,064	4,083	2,947	4,566	262,996
1924	11,962	10,610	50,127	25,741	21,456	18,553	14,416	9,988	8,440	5,537	9,165	46,533	232,528
1925	67,503	133,687	350,767	140,360	41,910	29,459	22,598	24,691	16,270	9,151	6,879	8,440	851,715
1926	125,443	21,166	21,160	24,202	12,493	9,647	6,867	5,483	6,533	4,257	2,938	12,508	252,697
1927	57,744	341,226	60,395	117,125	32,297	25,638	21,320	14,580	10,508	8,755	6,782	15,572	711,942
1928	14,580	134,012	166,228	24,703	17,053	12,945	13,161	10,505	7,897	6,530	8,768	11,431	427,723
1929	204,996	358,640	175,101	66,298	26,808	22,929	17,718	13,736	8,985	8,088	6,716	7,565	917,580
1930	414,180	314,315	57,988	32,849	29,222	25,252	19,123	15,146	11,761	21,119	10,898	15,230	967,083
1931	28,192	76,044	16,134	28,851	14,353	20,178	13,069	10,649	7,386	6,485	8,711	32,516	262,568
1932	273,795	37,489	81,559	20,680	32,626	22,337	16,139	12,491	9,868	6,622	4,818	26,017	544,441
1933	15,196	264,473	38,114	106,008	55,072	33,087	27,967	26,356	18,204	15,235	26,828	30,369	656,909
1934	261,651	436,726	462,564	90,707	70,388	47,356	37,625	26,706	22,174	18,206	18,431	13,519	1,506,053
1935	12,981	39,939	322,221	26,188	27,212	21,117	22,381	15,444	11,717	12,457	8,034	8,680	528,371
1936	21,643	257,314	194,918	50,222	32,267	48,439	31,268	23,801	17,294	12,885	9,527	12,711	712,289
1937	39,518	45,646	182,887	17,456	9,959	10,641	11,068	9,011	7,869	6,664	11,750	9,133	361,612
Total	2,170,450	3,436,497	3,520,956	1,850,844	769,525	540,059	430,695	352,326	282,361	236,007	218,987	582,240	14,380,947
Means	98,657	156,204	160,043	84,129	34,978	24,548	19,577	16,015	12,835	10,273	9,954	26,465	653,679
Runoff inches ..	2·51	3·98	4·07	2·14	·90	·62	·51	·41	·32	·26	·26	·67	16·65
Av. Ac. ft.–sq. mile	134	212	217	114	48	33	27	22	17	14	14	36	888
1938	116,024	308,698	39,861	19,300	14,900	12,800	..	..	..	..	..	..	..

Discharges given in acre feet.

TABLE 73.

DISCHARGE OF BARRON RIVER AT MAREEBA.

BASIN II–4–1. A.M.T.M. 43·6. CATCHMENT AREA 332 SQUARE MILES.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1916	8,956	12,052	10,210	6,022	7,563	5,355	6,026	5,792	5,822	4,784	5,639	31,074	109,205
1917	29,231	17,661	32,759	17,520	10,715	9,921	7,452	5,323	6,056	6,121	9,959	23,110	177,828
1918	49,960	56,343	48,681	39,404	21,061	13,420	11,475	10,308	7,682	7,490	7,464	8,148	281,436
1919	9,560	6,635	10,828	10,433	20,972	11,556	8,156	7,103	6,716	6,339	5,494	4,604	108,396
1920	12,528	20,146	15,928	7,696	9,289	5,324	4,189	3,727	3,376	4,280	4,153	8,097	98,733
1921	11,600	12,256	208,972	195,047	44,609	32,270	37,091	22,646	16,614	14,755	13,008	16,229	625,097
1922	29,628	109,473	123,981	40,971	35,396	20,361	131,813	131,506	124,484	123,493	120,835	130,951	1,122,892
1923	46,664	10 889	56,153	92,360	40,346	30,588	27,188	26,256	5,445	2,825	2,249	17,838	358,801
1924	18,306	17,177	79,925	16,521	11,185	9,376	5,278	3,556	2,588	2,481	3,447	43,758	213,598
1925	..	..	..	94,344	30,713	20,409	15,032	12,189	9,032	6,786	5,276	21,643	215,424
1926	66,281	16,164	22,271	17,487	9,953	8,317	6,716	5,486	5,058	4,302	3,328	20,650	186,013
1927	46,969	224,022	49,334	66,148	25,674	22,257	17,520	12,813	9,570	8,253	6,665	14,452	503,677
1928	11,344	54,758	63,301	23,431	14,950	11,205	11,546	9,211	7,194	5,705	8,327	12,127	233,099
1929	85,126	152,079	116,449	56,157	29,655	18,573	16,082	12,871	9,931	8,376	7,988	8,136	521,423
1930	161,469	157,885	37,476	30,274	22,302	18,774	14,939	12,868	9,582	10,134	9,521	11,986	497,210
1931	15,753	43,937	11,078	11,016	8,374	9,951	7,999	6,298	4,723	4,211	10,352	27.257	160,949
1932	97,420	24,205	48,134	16,987	18,875	15,572	11,631	9,445	8,047	6,286	4,709	11,921	273,232
1933	21,906	100,111	23,832	52,126	27,469	22,408	20,843	18,812	14,142	10,927	13,744	18,764	345,084
1934	133,549	188,970	273,665	94,460	70,133	38,014	28,908	22,445	16,987	13,890	15,600	11,330	507,951
1935	11,863	14,430	127,065	21,876	21,194	17,239	13,845	11,663	8,833	9,662	6,526	6,319	270,515
1936	14,587	56,089	84,838	33,099	25,803	27,021	23,389	15,926	13,401	10,247	7,888	15,965	328,253
1937	12,633	26,456	57,476	18,468	11,308	8,767	8,013	8,886	6,452	5,534	6,536	7,642	178,171
1938	26,047	94,839	30,006	15,447	11,881	10,251	11,567	7,810	5,645	5,853	9,331	4,958	233,635
1939	15,640	149,778	194,232	75,254	43,139	36,239	22,378	17,792	13,331	11,068	9,346	9,088	597,285
1940	15,051	57,700	202,700	69,373	36,078	31,857	24,342	17,471	11,976	10,233	9,061	7,458	493,300
1941	15,473	70,777	74,897	112,211	44,151	32,944	22,644	17,013	13,464	10,717	10,239	10,134	434,664
1942	9,229	35,636	14,739	12,978	15,123	12,447	13,746	8,489	9,666	11,473	10,884	28,967	183,377
1943	17,760	115,085	57,603	20,726	15,828	12,256	10,515	9,394	9,341	10,974	12,544	11,283	303,309
1944	10,789	35,530	26,625	19,628	10,314	10,088	13,221	9,334	6,523	6,459	4,587	9,345	162,443
1945	32,793	178,815	207,845	102,120	52,580	34,443	27,511	19,375	14,216	11,966	10,086	10,802	702,552
1946	24,508	79,588	95,956	21,521	16,041	11,352	10,572	8,934	7,595	6,107	5,113	5,143	292,430
1947	5,813	15,316	31,208	14,862	7,018	8,243	10,003	15,001	6,386	5,929	4,712	4,634	129,125
1948	20,164	9,868	35,957	11,839	11,024	10,624	10,996	8,230	6,034	4,487	3,082	3,031	135,336
1949	16,680	114,430	104,249	105,711	36,077	21,419	16,993	13,960	11,534	9,748	9,709	10,496	471,006
Total	1,105,280	2,279,100	2,578,283	1,449,173	786,080	588,432	614,587	517,744	408,414	375,109	372,126	565,697	11,640,025
Means	33,493	69,064	98,130	43,914	23,821	17,831	18,624	15,689	12,376	11,367	11,277	17,142	352,728
Runoff (inches) ..	1·89	3·90	4·41	2·48	1·34	1·01	1·05	0·89	0·70	0·64	0·64	0·97	19·92
Av. Ac. ft.–sq. mile	100·9	208·0	235·3	132·3	71·7	53·7	56·1	47·3	37·3	34·2	34·0	51·6	1,062·4
1950	25,679	24,060	112,637	85,795	..	..	..	..	..	..	..	..	..

Discharges given in acre feet.

TABLE 74.

DISCHARGE OF BARRON RIVER AT PICNIC CROSSING.

BASIN II–4. A.M.T.M. 78·88. CATCHMENT AREA 88 SQUARE MILES.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Total.
1926	16,528	7,277	8,686	8,797	5,143	3,267	2,622	2,307	1,964	1,748	1,461	4,397	64,197
1927	20,947	58,781	39,133	28,399	20,485	15,850	6,384	5,055	3,985	3,284	1,889	1,912	206,104
1928	6,386	20,875	41,913	9,383	6,500	3,685	3,100	2,507	2,009	1,541	2,612	1,376	101,887
1929	17,396	27,691	31,125	21,620	9,927	6,515	5,425	4,304	2,511	2,029	2,033	2,104	132,680
1930	23,481	38,274	13,264	8,247	8,384	6,121	4,212	3,317	1,989	2,482	1,768	1,685	113,224
1931	2,060	20,800	4,455	6,770	3,597	4,425	2,507	1,928	1,355	1,196	2,382	6,665	58,140
1932	23,889	9,188	20,460	7,216	9,065	9,735	4,711	3,170	2,352	1,791	1,438	2,299	95,314
1933	2,614	29,294	9,604	16,921	16,166	12,183	10,326	6,514	4,187	3,509	3,667	3,406	118,391
1934	35,209	52,823	53,743	24,266	22,957	17,231	14,674	7,295	5,707	4,001	6,669	3,043	247,618
1935	2,916	2,731	46,715	8,751	8,727	6,633	4,655	3,527	2,614	2,202	1,821	2,176	93,468
1936	2,745	14,648	24,703	15,219	13,404	13,490	11,863	7,876	5,486	4,021	2,751	3,902	120,108
1937	3,638	6,105	14,218	4,239	3,102	2,450	2,707	2,525	1,791	1,412	1,327	1,291	44,805
1938	4,806	29,350	10,548	5,673	4,552	3,836	4,107	2,918	2,074	1,812	1,588	1,383	72,647
1939	4,388	41,552	54,770	24,806	14,408	12,736	7,490	5,316	3,867	3,248	2,751	2,402	177,734
1940	3,295	22,178	54,495	26,383	14,710	16,435	11,012	7,113	5,213	4,046	3,395	2,631	170,906
1941	5,442	24,399	37,054	45,010	27,848	16,120	10,965	7,823	5,595	4,286	3,806	2,973	191,321
1942	2,206	12,640	6,757	6,419	8,570	7,565	7,608	4,081	2,831	2,228	1,865	12,273	75,043
1943	12,833	27,345	24,224	8,860	6,776	5,127	4,028	3,000	2,452	1,942	1,832	1,555	99,974
1944	1,897	10,688	8,677	8,554	3,832	3,948	5,515	3,438	2,476	2,075	1,719	2,468	55,287
1945	10,780	61,494	57,734	36,320	21,081	11,380	9,445	7,150	5,421	3,786	2,618	2,882	230,091
1946	9,467	30,450	34,588	9,430	7,286	5,429	4,428	3,317	2,206	1,738	1,500	1,507	111,346
1947	2,077	5,578	9,630	6,024	2,608	2,664	1,928	7,272	2,626	2,473	1,793	1,733	46,406
1948	12,730	7,654	19,803	5,986	4,715	5,909	4,892	3,904	2,360	1,534	804	775	71,066
1949	2,088	29,030	38,944	37,312	15,874	8,942	6,958	5,230	3,685	2,389	2,628	2,090	155,170
Total	229,818	590,845	665,243	380,605	259,717	201,676	151,562	110,887	76,756	60,773	56,117	68,928	2,852,927
Average acre feet	9,576	24,619	27,718	15,859	10,822	8,403	6,315	4,620	3,198	2,532	2,338	2,872	118,872
Runoff (inches) ..	2·04	5·25	5·91	3·38	2·31	1·78	1·35	0·98	0·68	0·54	0·50	0·61	25·33
Av. Ac. ft.–sq. mile	109	280	315	180	123	95	72	53	36	29	27	33	1,351
1950	9,745	12,992	40,983	33,158	16,074	14,043	10,098	6,651	4,784	..	..	..	..

Discharges given in acre feet.

TABLE 75.

TINAROO DAM SITE.

Estimated Quarterly Inflow (Thousands of Acre Feet).

Year.	1st Q.	2nd Q.	3rd Q.	4th Q.	Year.	1st Q.	2nd Q.	3rd Q.	4th Q.
1911	334	130	25	16	1932	130	52	24	14
1912	85	77	25	15	1933	105	103	48	27
1913	432	58	25	21	1934	372	156	60	32
1914	161	59	28	17	1935	128	56	32	19
1915	25	42	25	21	1936	119	94	59	26
1916	62	61	30	28	1937	63	25	17	12
1917	83	63	26	26	1938	106	30	20	13
1918	173	73	27	17	1939	205	116	39	20
1919	41	85	27	14	1940	192	118	47	22
1920	79	76	26	21	1941	138	174	48	24
1921	308	118	29	20	1942	47	42	29	38
1922	173	60	26	20	1943	144	42	21	18
1923	131	59	25	18	1944	51	33	24	15
1924	118	68	31	25	1945	303	150	48	23
1925	208	82	26	18	1946	160	44	22	11
1926	62	22	16	15	1947	39	24	25	13
1927	264	141	32	18	1948	73	32	22	8
1928	149	46	19	15	1949	166	132	34	19
1929	207	90	29	15					
1930	209	52	24	17	Totals ..	5,912	2,916	1,155	758
1931	67	31	15	27	Average ..	152	75	30	19

TABLE 76.

WALSH RIVER ABOVE NULLINGA DAM SITE—RUNOFF AS ESTIMATED FROM RAINFALL

COMPARISON OF METHODS.

Year.	Annual rainfall.	Method A. runoff from monthly totals.		Method B. runoff from individual storm totals.		Method C. runoff by evapo-transpiration method.
	inches.	Acre feet.	Inches.	Acre feet.	Inches.	Inches.
1895	43·38	60,000	9·0	..	..	14·1
1896	39·54	43,000	6·4	..	..	10·7
1897	35·47	1,600	2·7	..	..	0
1898	45·88	90,000	13·5	..	..	23·3
1899	45·10	115,000	17·2	..	..	23·1
1900	23·64	2,000	·3	..	..	1·0
1901	38·20	24,000	3·6	..	..	10·4
1902	23·41	6,000	0·9	..	..	0
1903	62·18	94,000	14·1	..	..	31·7
1904	41·08	104,000	15·6	..	..	28·7
1905	24·78	1,000	0·15	..	..	2·7
1906	46·62	15,000	2·25	..	..	5·1
1907	39·47	61,000	9·15	..	..	8·7
1908	32·27	48,000	7·20	..	..	11·1
1909	35·66	3,000	.45	..	..	1·9
1910	64·05	145,000	21·75	..	..	22·5
1911	60·47	270,000	40·0	..	..	39·4
1912	27·35	10,000	1·5	..	..	0
1913	70·62	242,000	36·0	..	..	36·3
1914	38·29	23,000	3·45	..	..	7·1
1915	15·06	2,000	0·30	2,000	0·30	0
1916	43·19	20,000	3·0	25,000	3·75	4·3
1917	43·22	32,000	4·8	40,100	6·0	11·8
1918	42·72	90,000	13·5	87,600	13·1	16·1
1919	22·31	2,000	0·3	1,500	0·2	0
1920	34·58	15,000	2·25	20,700	3·1	3·4
1921	56·27	100,000	15·0	102,000	15·3	14·5
1922	45·18	97,000	14·5	73,000	10·0	17·6
1923	26·09	12,000	1·8	5,300	0·8	0
1924	38·36	12,000	1·8	7,300	1·1	0
1925	40·50	32,000	4·8	25,500	3·8	8·5
1926	32·55	21,000	3·15	10,000	1·5	0
1927	47·69	106,000	15·9	77,000	10·5	17·2
1928	40·65	44,000	6·6	36,000	5·4	6·8
1929	51·26	130,000	19·5	117,000	17·5	24·0
1930	48·13	94,000	14·1	96,000	14·4	19·9
1931	31·78	3,000	0·45	3,800	0·57	0
1932	38·07	32,000	4·8	33,000	5·0	3·6
1933	50·24	38,000	5·7	33,800	5·0	7·3
1934	67·05	155,000	23·3	200,000	30·0	28·7
1935	35·28	32,000	4·8	38,000	5·7	0·6
1936	38·18	50,000	7·5	81,000	12·15	11·7
1937	35·29	26,000	3·9	32,000	4·8	3·1
1938	40·60	80,000	12·0	..	12·0	12·0
1939	63·81	168,000	25·3	..	25·3	23·2
1940	49·59	132,000	19·8	..	19·8	18·4
1941	49·56	80,000	12·1	..	12·1	14·7
1942	41·76	56,000	8·5	..	8·5	4·4
1943	34·45	100,000	15·0	..	15·0	16·7
1944	37·22	30,000	4·5	..	4·5	3·1
1945	64·76	217,000	32·5	..	32·5	26·8
1946	41·45	94,000	14·0	..	14·0	13·3
1947	40·62	27,000	4·0	..	4·0	4·1
1948	37·01	10,000	1·5	..	1·5	0
1949	61·96	150,000	22·5	..	22·5	26·0
1950	..	68,000	10·2	..	10·2	18·8

APPENDIX II.

GEOLOGICAL REPORT ON SITE OF NULLINGA DAM.

by C. S. Gloe, M.Sc. (Engineering Geologist.)

At the site of the dam the width of the river channel is approximately 400 feet, and, in addition, an alluvial flat some 400 feet wide has been formed on the left bank. Rock outcrops occur in the bed along the right bank, and on both flanks. These rocks consist of several varieties of acid igneous rocks of which the most important are granite, syenite porphyry and quartz felspar porphyry. Their age is thought to be Middle Palaeozoic and it is possible that they can be correlated with the Featherbed Porphyries.

In the vicinity of the dam site the granite occurs as a number of isolated small outcrops. The rock is a grey medium-grained biotite granite which, particularly in the smaller outcrops, shows evidence of some metamorphism.

The syenite porphyries are dark-grey to blue porphyritic rocks with phenocrysts of plagioclase and hornblende with some biotite set in a fine grained to glassy groundmass. The felspar and hornblende crystals characteristically occur as clusters or small aggregates. At its contact with the granite the syenite porphyry dykes become black and glassy and show flow structure parallel to the contact. One variant of this dyke rock has fairly abundant quartz phenocrysts in addition to those listed above.

The quartz felspar porphyry dykes are grey-blue porphyritic rocks with phenocrysts of quartz and felspar set in a fine to glassy siliceous groundmass. There are several variants, each of which shows a glassy phase with flow structure at its contact with older dykes. One of the variants, which is rather common shows a fair proportion of femic minerals, and is scarcely distinguishable from the more acid and quartzose of the syenite porphyries.

It is considered that subsequent to the emplacement of the granite in Middle Palaeozoic times the area which now includes the dam site was subjected to considerable tensional stresses. As a result a swarm of parallel dykes were intruded along the tensional faults. These dykes which were of the syenite porphyry type squeezed through and completely broke up the granite. The smaller blocks, which now appear as zenoliths in the dykes, suffered some metamorphism during this period. There are several larger granite outcrops in this area and these probably represented more massive blocks which, apart from several narrow syenite porphyry dkyes, appear to have been little affected by the subsequent igneous activity. It is these larger granite outcrops which form the best quarry sites in the area.

Tensional stresses were still active after the syenite porphyry dykes had cooled and resulted in a series of quartz felspar porphyry intrusions (the exact sequence of dykes has not yet been established and it is possible that there may have been some alternation in the order of intrusions). All the dykes are roughly parallel to each other and although in detail their contacts may be irregular, they are in general vertical. There is some evidence that a few of the intrusions have resulted in flat sill-like dykes.

The last stages of igneous activity occurred when a number of small quartz veins were intruded. Since that time weathering and erosion has been continuous until the present day. The dyke swarm has in general proved more resistant to erosion that the main granite mass and the range through which the Walsh River has cut its channel is very largely made up of these various dyke rocks. Strangely enough the range is not parallel to the dykes which cut acutely across the main ridge. As a result the dykes also cut across the proposed axis of the dam which is located more or less along the spur on the right bank. The strike of the dykes is approximately N45 degrees W.

In recent times the Walsh River has built up an alluvial flat along its left bank at the dam site. Apparently the river has gradually migrated towards the east and is still doing so, as there is a practically continuous rock outcrop along this bank of the river. The maximum depth of alluvium found in the drilling investigations was 41 feet. The present river channel has deposits of up to 30 feet of coarse sands and gravels with a small but variable proportion of interstitial clay. These gravels extend for some distance beneath the alluvial flat and are overlain and gradually replaced towards the left flank by sands and finally silts.

It is apparent from the shafts and diamond drill holes that hard sound rock either directly underlies, or occurs within a few feet of the base of the river alluvials. The soundness of the rock in this section is unaffected by the rock type. Towards the flanks, however, the depth of weathered rock gradually increases and diamond drill holes put down at or above crest level showed considerable depths of very jointed, iron-stained rock. Another feature as regards the soundness of rock on the flanks is the relatively frequent occurrence of totally decomposed granite. There are no surface indications of where this material occurs but it has been picked up in a number of shafts and diamond drill holes. Relatively little decomposed granite has been found along the axis line but an apparently large body of this material, which is up to 50 feet in depth, occurs just downstream of the axis on the right bank. It is also apparently very prevalent upstream of the axis on this bank.

In general, the various porphyry dykes show little difference in their degree of weathering. The finer and glassy phases tend to be more closely jointed but do not appear to be more deeply weathered than the coarser phases.

Although little difference could be picked up in diamond drill holes conditions revealed by

shafts sunk to date on the left bank differ from those found on the right bank. Sound rock occurs in shafts sunk near the axis on the right bank at depths of from 11 to 24 feet. In several shafts the overlying rocks showed some semi-horizontal joints filled with up to eight inches of totally decomposed material. However, once solid rock is encountered it apparently persists. Shafts on the left bank indicated that continuous sound rock had not been encountered at depths of 31 and 34 feet. Most of the rock was sound at shallower depths but weak joints filled with clay, and calcite-zeolite mixtures persisted to the bottom of the shafts. In one of the shafts a slow seepage of water proved these joints to be pervious.

Grouting tests would have to be carried out to determine to what extent the various types of joints found in the area can be sealed. The depths of foundation level are to some extent dependent on these results. However most of the rock, including the totally decomposed granite, appears to be a suitable foundation for an earth dam.

The permeabilities of the various water-bearing materials varies considerably. Two shafts in the river bed required continuous pumping at 6,000 gallons per hour to keep them free of water while two other river bed shafts yielded only about 500 gallons per hour. Further pumping tests are in progress to determine the total underflow through the alluvials.

APPENDIX III.

BUREAU OF INVESTIGATION.

MAREEBA–DIMBULAH RECONNAISSANCE SOIL SURVEY.

Report by Messrs. P. J. Skerman and G. H. Allen, November, 1950.

A reconnaissance survey of the soils of the Mareeba-Dimbulah area which would be commanded by the proposed dams at Tinaroo Falls, on the Barron River, and the Nullinga Dam, on the Walsh River, was carried out between 15th September and 11th October, 1950.

The Irrigation Commission made a jeep available for the purposes of the survey and supplied the Bureau officers with aerial photographs of the Mareeba and Dimbulah areas flown by Adastra in August, 1949, under the direction of the Irrigation Commission. These photographs ceased at Biboohra to the north and the area between Biboohra and Southedge was covered by only a very broad reconnaissance, and later mapped from the aerial photographs of the Biboohra area held by the Army at Victoria Barracks.

Survey Procedure.

Roads were used for the traverses in most cases, with deviations to inspect the varying types of country as indicated by the aerial photographs; and soil borings were made as required. It might be mentioned here that while aerial photographs are a distinct help in this work, the vegetation in North Queensland does not follow soil patterns so much as it does in Southern Queensland, and much more boring is required in the north to delineate soil types. Vegetation notes were taken at each boring site and the geology was noted at creek crossings, outcrops, &c.

Land Use Discussions.

Discussions on land use were held with officers of the Department of Agriculture and Stock (Mr. Hamilton of Mareeba, 2 days; Messrs. Steele, of Atherton and Baird, of Mareeba, one day each) and with Mr. Clarke of the Irrigation Commission, who accompanied us for one day. Land use was also discussed with farmers throughout the area.

Geology of the Mareeba-Dimbulah Area.

The Tolga-Mareeba area is a continuation of the basaltic flow of the Atherton Tableland, and floating boulders, usually 18 inches to 24 inches in diameter, are common on the surface of the ground, particularly in the Turkinje-Mareeba section. This basaltic flow extends in a finger-like flow westwards to form the divide between Granite and Maud Creeks with the main body lying west of Atherton Creek. It is dissected by the Barron and Tinaroo Creeks and then extends north-eastwards in intermittent plugs to Davies Creek.

Fine-grained schists containing veins of quartz occur between Tinaroo, Levison, Emerald, and Shanty Creeks, and this formation appears again north of Boyle Creek west of Biboohra and on the Leadingham Creek watershed. These schist areas give rise to fine grained soils. Some outcrops of a type of schistose sandstone occur in the Pinnacle Creek valley and at Biboohra.

The major portion of the area is made up of a coarse-grained granite from which is also derived a coarse conglomerate rock which is often found capping the granite boulders throughout the area. The soils arising from the granite and conglomerate are generally somewhat gritty especially in the lower horizons.

Rhyolitic and porphyritic rocks occur in the vicinity of the Nullinga Dam site.

Lateritic influence is widespread throughout the area but no massive laterite was encountered.

The Soils of the Mareeba-Dimbulah Area.

The influence of geology is reflected in the soil distribution throughout the area, the basaltic soils giving rise to red clays which have been subjected to varying degrees of laterisation; the schists, granites and conglomerate providing sandy soils, the former fine grained, the latter coarse grained with or without grit and gravel.

Soils of Basaltic Origin (Blue on Map).

A large area comprising a gross acreage of 27,950 acres of red to red-brown light clay soils occurs in a continuous belt between Tolga and Mareeba and extends westwards for two to three miles on either side of the main road with further patches west of Levison and Emerald Creeks. The soils consist of shallow red loams on the slopes of the basaltic outcrops, deep lateritic red loams or red earths in the centre of the areas with a tendency towards full laterisation around the margins, the exact distribution of these three types would have to be determined by detailed survey. The soils are all residual on basalt and the basalt in most cases is somewhat vesicular.

Typical profiles examined are represented hereunder:—

(1)	0″–18″	red light clay, slightly compact surface, dry and fairly hard boring.
	18″–36″	red light clay, occasional ironstone shot.
	36″	red light clay, friable, mellow.
		Vegetation: box, bloodwood, Themeda australis grass.
(2)	0″– 4″	red-brown light clay, compact surface, odd ironshot.
	4″–68″	red light clay, friable, odd ironstone, mellow.
	68″–72″	red medium clay.
		Vegetation: box and bloodwood, Themeda australis grass.
(3)	0″– 6″	brown to red-brown light clay, friable.
	6″–33″	yellow-brown light clay, friable.
	33″–45″	yellow-brown light clay with ironstone concretions.
	45″	weathered vesicular basalt.
		Vegetation: box and bloodwood, some loose vesicular basalt stones on the surface. Themeda australis grass.

In a previous report a large area of these soils was rejected as unsuitable because of the presence of boulders. However, the advent of the bulldozer has made possible the removal of floating boulders up to 3 feet in diameter and a good deal of clearing has been accomplished with the stones being piled in rows along the headlands. Under these circumstances possibly only about ten per cent. of the area need be rejected because of stoniness.

At present these soils are generally utilised for summer cropping, the rainfall received being considered adequate for this purpose. Crops include maize, peanuts and cowpeas chiefly. Some dairying is being conducted on natural pastures. Only a small percentage of the area is cultivated. Some tobacco growing has extended to these soil types in recent years and one would expect the light clay to produce a fairly heavy leaf. However, it has been shown that provided rain does not fall as the crop is reaching maturity quite good crops of tobacco can be grown. If rain falls towards maturity the leaf quickly gains body and is difficult to cure. Under present tobacco prices this crop gives the highest return per acre and so there will be a tendency to extend plantings on these soil types. The clay retains moisture longer than the sandier soil types. In an attempt to cut down on the nitrogen supply the standard 4-12-6 and 3-8-3 fertiliser mixtures are being broken down in nitrogen and a boost given to the phosphate portion, and 2-17-4 and 2-14-4 mixtures are at present under trial.

Cartmill states that "the suitability of these soils for tobacco growing is probably related to their clay and free iron oxide content. Good quality tobacco can be grown on the brown and red-brown soils, but not on the red soils. The former group are lighter in texture than the latter and contain less free iron oxide. The reason for the difference in quality of the leaf from the two groups is thought to be in the absorption and precipitation of phosphates. The red soils are high in kaolinitic clay which absorbs phosphates readily, and are high in free iron oxide which precipitates the phosphate. Although the available phosphate may be sufficient for plant growth the tobacco plant cannot absorb the luxury amounts required to give colour and quality to the leaf when grown in the red soils; on the lighter textured brown soils absorption and precipitation of phosphates is not so high and provided they are heavily fertilised with phosphate the colour and quality of the leaf grown on them is satisfactory. The red soils are very suitable for the production of other agricultural crops."

Given irrigation water these soils would be suitable for a wide range of production. It should not be a difficult matter to arrive at suitable pasture mixtures for stock raising as the Atherton Tableland types would be readily applicable. Irrigated dairying suggests itself as a distinct possibility while cotton growing should be profitable. Market prices and demands for other lines of produce would determine the chances of irrigating hybrid maize, peanuts, cowpeas, arrowroot, pineapples, &c., economically. Beef cattle fattening would also be a possibility if its economy is proved, as store cattle are handy and the dry tableland climate is healthy.

Soils of Schist Origin.

As has been mentioned earlier, the soils derived from schist are generally fine-grained and are represented by grey and grey-brown fine sands and sandy loams with yellow or grey-brown lower horizons. Quite frequently the depth of the solum is too shallow for cultivation and a large area of schist country has been excluded from the irrigable area because of this.

Quartz veins commonly occur in the schist and a good deal of prospecting and mining has been carried out in these areas in the past. Five main types of soils of schist origin have been described—represented by soils III., IV., VIII., IX., and XIV. with profiles as follows:—

III. (small blue dots on map)—

0″– 6″	grey-brown fine loamy sand.
6″–15″	light grey-brown fine sand.
15″–27″	yellow-grey fine sand.
27″–40″	red-brown fine sand.
40″–48″	red fine sandy clay.
48″ +	red fine sandy clay with quartz gravel.
	Vegetation: bloodwood and ironbark.

IV. (thin diagonal blue lines on map)—

0″– 9″	light-grey brown fine sand.
9″–23″	yellow-grey brown fine sand.
23″–27″	red-brown light clay, with some ironstone concretions.
27″ +	red light clay, friable with lot of ironstone.
	Vegetation: poplar gum and bloodwood.

VIII. (thick blue diagonal crossed lines on map)—
0″– 3″ grey fine sand.
3″–30″ light-grey brown sand.
30″ + grey-brown mottled sandy clay.
Vegetation: bloodwood.

IX. (green on the map)—
0″– 3″ grey fine sandy loam.
3″–12″ light-grey brown loam plus a little ironstone.
12″–15″ yellow-grey brown sandy clay loam and ironstone.
15″–27″ yellow-grey brown gravelly sandy clay—gravel is ironstone and schist.
Vegetation: box, odd ti-tree.

XIV. (yellow on map). The profile varies but can be represented as follows:—
0″– 3″ grey fine sand.
3″–18″ light-grey or grey-brown fine sand.
18″–27″ yellow-grey brown sandy clay or medium clay + ironstone and some mottling.
Vegetation: Poplar gum and grevillea.

Type III. soil is somewhat limited in area, totalling 790 acres gross, but it is suitable for the growth of most crops, including tobacco. In a very wet season there may be some damage from waterlogging in the fine sands but this is unlikely when crops are planted and matured in the "dry" with the aid of irrigation.

Type IV. soils are found on the lower slopes where drainage has been slightly impeded and ironstone has accumulated. However, the depth of the solum and the slope of the land would protect this soil from drainage problems. The gross area of this soil type is 4,860 acres. (It is opportune to mention here that 530 borings were made in the Mareeba-Dimbulah area during this September-October survey and in only one case was free water encountered and that in a swamp. As the planting-out period for tobacco is late September to October and a maximum application of 2 acre feet of water per acre is applied during the 2½ months' growing period, it is not considered that waterlogging and drainage problems will arise as would be expected if crops were grown through the wet season.)

Type VIII. soil occurs chiefly on the western watershed of Cattle Creek and is derived from the rocks of the McLeod range which give rise to an alluvial counterpart on the western side of the range. These soils are suitable for tobacco-growing and for the growth of a range of agricultural crops including cotton and citrus. The gross area of this type is 2,110 acres.

Type IX. soils occur in a large belt on the western side of the Leadingham Creek valley. They have more clay in them than the other schist soils having a sandy loam in the A horizon. They are a little shallow but the schist soils are fairly stable and would not readily erode.

A variant occurs on portions 86, 87, and 110, parish of Leadingham, where river gravel is found with the schist gravel at 18 inches depth.

The gross area of these soils is 6,020 acres.

Type XIV. soil occurs on gentle slopes and there is some evidence of impeded drainage. With careful watering and good drainage the deeper phase of this soil type could be used for tobacco growing. This soil is very similar to types XXIV. and XXV. and the gross area of the three types is 27,470 acres and it is estimated that perhaps half would be suitable for tobacco growing but a detailed survey would be necessary to check this estimate.

Recent Alluvial Soils—Type V.

These soils occur as levees or flats adjoining most of the streams throughout the area and have been mapped as alluvial sandy loams and loams; and alluvial sands. The alluvial loams and sandy loams are probably the best soils in the district for general agricultural purposes and their value is enhanced by proximity to water. Consequently most of the alluvial soils are at present being cropped where sufficient water is available, chiefly with tobacco. The profiles for the various streams are set out below:—

Barron River alluvium—(Biboohra).
0″– 6″ brown loam (fine sand).
6″–12″ brown light clay, friable.
12″–36″ + brown medium clay, hard; lot of fine mica in clay.

Tinaroo Creek alluvium—
0″– 6″ grey-brown gritty loamy sand.
6″–15″ yellow-grey brown clayey sand.
15″–21″ yellow-grey brown friable.
21″–57″ brown medium clay, gritty with some small gravel.
57 + brown friable clay, gritty with small gravel—lot of mica and granitic minerals in grit.

Emerald Cerek alluvium—
0″– 6″ brown sandy clay loam.
6″–20″ red light clay, friable, odd soft iron.
20″–39″ yellow-red medium clay with some ironstone and grit.

Horse Creek alluvium—
0″– 6″ red sandy loam.
6″–12″ red clay loam.
12″–24″ red sandy clay.

Leadingham Creek alluvium—
0″– 3″ grey-brown loam.
3″–12″ light-grey brown clay loam.
12″ + brown light clay.
Vegetation: box, odd ironwood.

McLeod Creek alluvium—
0″– 6″ grey-brown loamy sand.
6″–24″ light-grey brown sandy loam.
24″ + grey-brown clayey sand.
Vegetation: box, ironwood.

Castle Creek alluvium—
0″– 3″ grey-brown sandy loam.
3″–18″ brown sandy loam.
18″ + brown sandy clay loam.
Vegetation: box, ironwood.

Granite Creek alluvium—
0″– 3″ dark-grey fine sandy loam.
3″– 9″ light-grey fine sandy loam.
9″–15″ light-grey brown loam.
15″ + light-brown light friable clay.
Vegetation: bloodwood, Moreton Bay ash.

The gross area of the alluvial soils is 18,050 acres.

The Soils derived from Granite and Conglomerates.

In the Dimbulah-Mareeba area the granitic rocks are coarse grained and on weathering they give rise to a conglomerate-like mass. Quite frequently, both in creek beds and on elevated scarps a layer of three feet or so of conglomerate overlies granitic boulders and it is obvious that the conglomerate has been derived from the granite. Consequently it would be expected that the soils derived from these two rock formations would be similar and this is found to be the case.

The soils are usually of a sandy nature with some grit at or near the surface and frequently with some gravel in the deeper horizons. They

usually have a grey-white or grey-brown sandy surface. This group is represented by the following soils:—

II. (thick blue diagonal lines on map)—
- 0″– 3″ dark-grey brown slightly gritty loamy coarse sand.
- 3″– 9″ grey-brown slighty gritty loamy coarse sand.
- 9″–18″ reddish grey-brown sandy clay loam, slight grit.
- 18″–54″ red light clay, friable, slight grit.

Vegtation: blood and ironwood (*Erythrophleum* spp.).

VII. (horizontal blue lines on map)—
- 0″– 9″ grey sand, light grit.
- 9″–15″ grey-brown gritty sand.
- 15″–30″ yellow-grey brown clayey sand with quartz grit.
- 30″ + brown gravelly clay—quartz gravel.

Vegetation: bloodwood and ironwood.

XV. (thin yellow diagonal lines on map)—
- 0″– 4″ grey gritty coarse sand.
- 4″–15″ light-grey gritty coarse sand.
- 15″–24″ yellow-grey gritty coarse sand.

Vegetation: Pandanus, ti-tree, poplar gum.

XXII. (brown crossed lines on map)—
- 0″– 3″ grey-brown loamy grit and small gravel.
- 3″–24″ red-brown loamy grit and small gravel.
- 24″ + red sandy grit—grit is all quartz.

Vegetation: Bloodwood, Hakea, Grevillea, and Eucalyptus miniata.

XXIII. (thick blue diagonal crossed lines on map)—
- 0″– 3″ grey to yellow-grey fine sandy loam.
- 3″– 9″ yellow-grey clay loam with odd ironstone.
- 9″–21″ yellow-grey brown light clay, friable with odd ironstone.
- 21″–40″ yellow-red brown friable clay.

XXIV. (yellow with brown dots on map)—
- 0″– 3″ grey fine sand.
- 3″–12″ grey-brown fine sand.
- 12″–21″ yellow-grey brown slightly clayey sand, slight grit.
- 21″–24″ yellow-grey brown gritty sandy clay.
- 24″–27″ grey-brown gritty clay.
- 27″ + decomposed granite.

Vegetation: oak and poplar gum.

Type II. soil is a most attractive one for tobacco growing and general agriculture. It belongs to the red loam great soil group but has a somewhat sandier surface than is usual with these soils. At present these soils are not fully utilised because of the lack of water for irrigation. Topographically they occur on the higher slopes, and in the Paddy's Green area are situated above the proposed channel line and so will demand an additional pumping. The highest priced tobacco at the last season's sales was grown on this type of soil. The gross area of this soil type is 26,070 acres.

Type VII. soil consists of somewhat gritty sands with quartz gravel in the lower horizons. They have been used to grow tobacco in the past and given water will be capable of growing this crop in a rotation of one in three or four. The gross area of this soil type is 4,360 acres.

Type XV. soil is fairly common on granitic slopes, usually bearing a cover of Pandanus palm with some ti-tree and odd bloodwood. It is generally light coloured gritty sand which does not produce a good quality leaf. In the early days of settlement much of this type was cultivated but many of the trial areas were abandoned later. Where irrigation channels are passing through this soil type no doubt tobacco growing will again be tried in long term rotations. The gross area of this soil type is 11,360 acres.

Type XXII. soil is the most coarsely-textured soil in the area and consists of gritty and gravelly residual material near the foothills of the ranges. The vegetation of bloodwood is very attractive-looking but the waterholding capacity of the soil would be low and leaf quality would probably be poor. There is a gross area of 2,345 acres of this soil type.

Type XXIV. soil is very similar to type XIV. developed on schist. The soil derived from granite occurs on slopes and in general drainage problems will not be severe. Leaf quality may not be as good as that from Type II. but with the correct use of fertilizers it should be satisfactory.

The Podsolised Old Alluvial Soils.

In the older alluvial soils podsolisation has proceeded to produce a series of soils with a very heavy clay at a shallow depth. The topography in this case is usually flat and the vegetation consists of poplar gum and box. The surface soil may be a fine powdery (floury) sand or sandy loam which runs together on wetting. Internal drainage is slow because of the heavy clay horizon. This group is represented by the following type profiles:—

Type X. (heavy blue dots on map)—
- 0″– 3″ grey medium sand.
- 3″–22″ light-grey brown medium sand.
- 22″ grey-brown heavy clay, slightly friable.

Vegetation: box and poplar gum.
Gross area: 7,140 acres.

Type XI. (diagonal brown lines on map—gross area 10,600 acres)—
- (i.) 0″–10″ white very fine sand.
  - 10″ + heavy brown mottled blocky clay.

  Vegetation: box and poplar gum.
- (ii.) 0″– 4″ grey-white sandy loam.
  - 4″ + grey-brown blocky heavy clay.

  Vegetation: poplar gum.

Type XII. (brown dots on map)—
- 0″– 9″ grey-brown mottled clay—compact.
- 9″–12″ yellow-grey brown mottled heavy clay, blocky.

Vegetation: box.
Gross area: 7,860 acres.

Type XVI. (yellow dots on map)—
- (i.) 0″– 5″ grey-brown sand.
  - 5″ + grey-white sand with abundant large ironstone.

Gross area: 1,820 acres.

A further series of podsolised sandy soil types is found throughout the area carrying timber cover of which ti-tree is usually a dominant. The topography is flat and in the wet season there is undoubtedly some waterlogging, and ironstone has accumulated just above the clay horizon in the lower profile. There may be some slight solonisation in the clay horizon. Some tobacco is being grown on the deeper phases of this soil group and it is yet too early to determine the quality of the leaf grown. The shallow phase is unattractive. Typical profiles are as follows:—

Type XXV. (yellow with diagonal brown lines on map)—
- (i.) 0″– 4″ light-grey fine sandy loam.
  - 4″–12″ yellow-grey sandy clay loam.
  - 12″–18″ yellow-grey light clay, mellow.
  - 18″–30″ yellow-grey brown light clay with ironstone.

  Vegetation: ti-tree scrub.
- (ii.) 0″– 3″ grey fine loamy sand.
  - 3″– 9″ grey clayey sand.
  - 9″–12″ grey sandy clay, odd ironstone.
  - 12″–30″ yellow-grey light clay, friable with red mottling and ironstone.
  - 30″–48″ grey medium clay, red mottled with abundant ironstone.

  Vegetation: ti-tree, quinine, box.

The Solonised Clays—Type XIII.

Between Paddy's Green and Tabacum a wide expanse of clay soils carrying a vegetation of box and poplar gum is encountered. The topography is flat but on close inspection the micro-relief exhibits slightly hummocky formation with hexagonal cracking to produce lenses on the surface of the soil some twelve feet in diameter. The cracks at the time of inspection were only about one-half inch wide. This hexagonal cracking resembles that exhibited by the Oaky series of soils in the Burdekin Valley which are somewhat solonised.

The typical profile is as follows:—

0″– 1″	dark-grey, slightly laminated, brown mottled dark-grey sandy loam.
1″– 3″	light-grey brown medium clay.
3″–20″	yellow-brown to yellow medium to heavy clay, slightly blocky with small ironstone pellets.
20″–24″	yellow-grey brown medium heavy clay with ironstone pellets.

The clay in this profile is not so heavy as that exhibited by the Oaky series, but the surface is a clay and if the profile is solonised as is suspected it will be more difficult to get water into than the Oaky series. Under these circumstances it is considered best at this stage to recommend it only for pasture production. Experimental work should be carried out on this soil type when water is available to determine for what further use the soil might be suitable. The gross area is 27,440 acres of which a large proportion occurs north of Biboohra and would probably be omitted from the irrigation schemes.

Colluvial-alluvial Soils.

Fanning out from the base of the foothills at the headwaters of Prince Creek south of Mutchilba and Algoma and approaching the Walsh River is a large area of somewhat gritty soil derived from colluvial material and related to the gritty type XXII. soil. A somewhat similar soil is found north of Boyle Creek. These gritty sands are being used near Mutchilba and grow tobacco successfully one year in three. The gross area is 2,070 acres. Typical profiles are—

Type XVII.—

(i.) Price Creek—

0″– 6″	grey gritty loamy sand.
6″–27″	grey-brown gritty and slightly gravelly sand.
27″–36″	brown, slightly clayey gritty and gravelly sand.

Vegetation: bloodwood and ironwood.

(ii.) Boyle Creek—

0″– 3″	grey medium sand, loamy sand.
3″– 9″	grey-brown medium sand—some grit.
9″–15″	yellow-grey medium sand—some grit.
15″–30″	yellow-brown gritty medium sand.
30″–50″	grey-brown gritty and gravelly sand.

Vegetation: poplar gum and bloodwood.

Miscellaneous Minor Types.

Type XIX is a small drainage area of twenty-three acres at the foot of a ridge. The profile is—

0″– 8″	dark-grey clay loam, compact surface, slightly mottled with ironshot present.
8″–12″	grey-brown friable gravelly clay and ironshot gravel.
12″–27″	yellow-brown friable clay with heavy ironstone concentration.

Vegetation: Poplar gum, bloodwood parkland.

Type XX. is the only black soil type encountered. It is residual on basalt but no lime accumulation is evident. Profile is—

Ao Surface boulders.

0″– ½″	dark-grey to black clay mulch.
½″– 2″	dark-grey to black heavy clay blocky, some grit.
2″– 6″	dark-grey to black heavy clay, plastic, some brown mottling.
6″–30″	dark-grey brown heavy clay, plastic, mottled, some grit.
30″–36″	dark-grey brown heavy clay, with soft iron inclusions and odd weathered basalt—probably on old swamp.

Vegetation: Open grassland.
Gross area: 12 acres.

Type XXI.—This soil is a grey sandy loam overlying yellow grey sandy light clay. It is suitable for tobacco production. The gross area is 73 acres.

General.

As mentioned earlier, ground water was encountered in only one boring of the five hundred odd profiles examined. Ironstone, however, was frequently met with. This ironstone may be the result of soil forming processes in the remote past and probably has no direct relationship with present soil moisture conditions. If such is the case it can be ignored, but some survey of the varying soil types in the wet season seems to be warranted just to see if there is any correlation between ironstone and waterlogging under present conditions. It is probable that only the "soft" red and brown inclusions are bound up with present soil moisture conditions.

Tobacco Growing in the Mareeba-Dimbulah Area.

In the "boom" days of the 30's tobacco growing was commenced on the white sands under natural rainfall conditions. Leaf quality from these areas was not satisfactory and with the crop growing during the wet season losses were inevitable. The tobacco farms gradually shifted from these white sands to the reddish types and the alluvials, especially where irrigation water was available. Consequently a large number of farms have been abandoned and a map is presented (Fig. 8) showing the distribution of farms growing tobacco and those which are out of production. The causes of abandonment appear from an inspection of this distribution and comparison with soil types to be about equally due to insufficient water and poor soil type.

Where possible irrigation is now being practised and the crop is grown in the "dry." In this way practically full control of growth can be accomplished with the aid of fertilizer and water. However, not all farmers have a water supply available and it was calculated that for last season 800 acres of tobacco were grown with the aid of irrigation, and 700 acres under natural rainfall conditions. It can be seen therefore that there is ample room for irrigation development. Present practice for irrigated crops is to plant out in the field in late September to early October and harvest the crop before the onset of the wet season. The demand for irrigation water for the tobacco crop appears to be somewhat higher than the figure of 1 acre foot per acre arrived at by the Bureau on its 1946 visit. At the Experiment Farm at Mareeba the annual requirement is in the vicinity of 21-24 inches per acre per annum.

The quality of the leaf produced on the area was discussed with buyers and with departmental officers and farmers. The buyers assert that there will always be a demand for the better North Queensland leaf even when American tobacco is again available. They say, however, that the leaf from the white sandy soils is somewhat inferior, and it was learned that the Biboohra and Clohesy River leaf is not of good aroma. The reasons for this are difficult to assess. The Biboohra soils differ only slightly from others in the district—the underlying clay is somewhat tougher and the area overlies sandstone whereas others are derived from granite, schist and basalt. Mr. Hamilton of the Department of Agriculture and Stock states that tobacco grown on the red basaltic soils is satisfactory if no rain falls in the later growing period, but if such happens the sudden upsurge of nitrogen produces a heavy leaf which is difficult to cure, and of poor quality. Farmers growing tobacco on such soils must risk periodical crop failure on this account, but as tobacco is such a high-value crop they seem to be prepared to accept this risk.

Several other problems remain to be investigated in connection with tobacco growing. With such a diversity of soil types within the area which have grown successful crops of tobacco it is difficult to reject some types from the irrigation proposals. The ability of the individual farmer may swing the balance in favour of some soil types as is being demonstrated by Pin at Mutchilba. It would seem that as soon as the experiment farm at Mareeba is suitably equipped and staffed, experimental work should radiate from this headquarters to ascertain the reaction of the various soil types to stabilised tobacco production.

The question of rotation crops also arises. At present prices for tobacco there is no real need for additional income from other crops, but the matter of soil maintenance for tobacco production is important. Rotation trials have been set in train by the Department of Agriculture and Stock and tobacco plants have made good growth in each case following Gambia pea, Rhodes grass and maize. Townsville lucerne (*Stylosanthes sundaica*) has spread throughout the sandy areas and should be an asset in rotation planning. It will be necessary to protect the slopes from erosion by storm waters during the wet season.

Other Crop Production.

At present maize, peanuts, and cowpeas constitute alternate sources of income to the tobacco growers. One or two men dairy on natural pastures and one farmer at Paddy's Green produces fat lambs (recently transferred to wool production). The maize and peanuts produced are marketed through their respective Boards at Atherton; the cowpeas are sold as seed for green manuring in the sugar areas. Present production of maize in the Mareeba-Dimbulah area is approximately 600 tons per annum from fourteen growers. Peanut production of 264 tons is made up of 220 tons of Virginia Bunch from 510 acres and 44 tons of Red Spanish from 189 acres. The quality of cowpea seed produced by somewhat crude methods of threshing and from planting impure seed, leaves much to be desired, but there is a good market for this material. About 8,000 bushels of seed are sold from this area annually. Additional crops which should be worth a trial in the area include cotton and broom millet, both of which have a good market outlet, and possibly arrowroot and soybeans when sufficient demand and an adequate price come from the manufacturers.

Citrus fruit do well in the sandy soils of the area but there is a limited market for the crop.

Vegetables were produced in large quantities in this area during the war years and if a market could be assured for canned vegetables and citrus juice these would be of great value to the district. Insect pests and diseases common to both tobacco and vegetables would have to be carefully controlled. At present market prospects for canned vegetables are not bright.

Animal Industry.

The establishment of animal industries in the proposed irrigation area would require to be reviewed in the light of the cost of providing water and the likely returns from dairying, pig-raising or cattle fattening. The sandier soils would probably demand too much water but the heavier types could be considered.

Dairying.

The basaltic soils which are generally considered too heavy for tobacco production could be brought into dairy production under irrigation. Factories for the treatment of milk and milk products and for bacon curing are already provided in the district. Pasture mixtures would have to be determined, but Tableland experience would provide a good lead. There appears to be a good outlet for more whole milk in North Queensland.

Cattle Fattening.

With store cattle immediately available cattle fattening would no doubt find a place when the economy of such is proved. One factor in favour of this practice is that store cattle can usually be obtained more cheaply near these breeding areas than further south.

SUMMARY OF MAREEBA-DIMBULAH SOILS

(as measured by the Irrigation Commission).

	Acres.
Soils suitable for tobacco, other crops, and pasture. (Types II., III., IV., V., VI., VII., VIII., IX., XVII., XXI., XXIII.)	59,358
Soils suitable for pasture, some crops, and possibly tobacco. (Types I., X., XIV., XXIV., XXV.)	68,136
Soils possibly suitable for pasture, but require experimentation to determine husbandry. (Types XI., XII., XIII., XIX., XX.) ..	53,406
Soils rather porous for irrigation, which will have a high water and fertiliser requirement—can be used for tobacco and citrus where channels have to pass. (Types XV. and XXII.)	8,577
Soils unsuitable for crops—may allow some pasture development. (Type XVI.) ..	1,521
Soils generally unsuitable for irrigation. (Type XVIII.)	12,206

N.B.—The above areas are gross. There may be deductions of up to 50 per cent. for gullies, excessive slope, drainage area, stones (in Type I.), fences, and headlands, and irrigation channels. The Irrigation Commission is deducting 20 per cent. to cover such losses.

The Clohesy River Area.

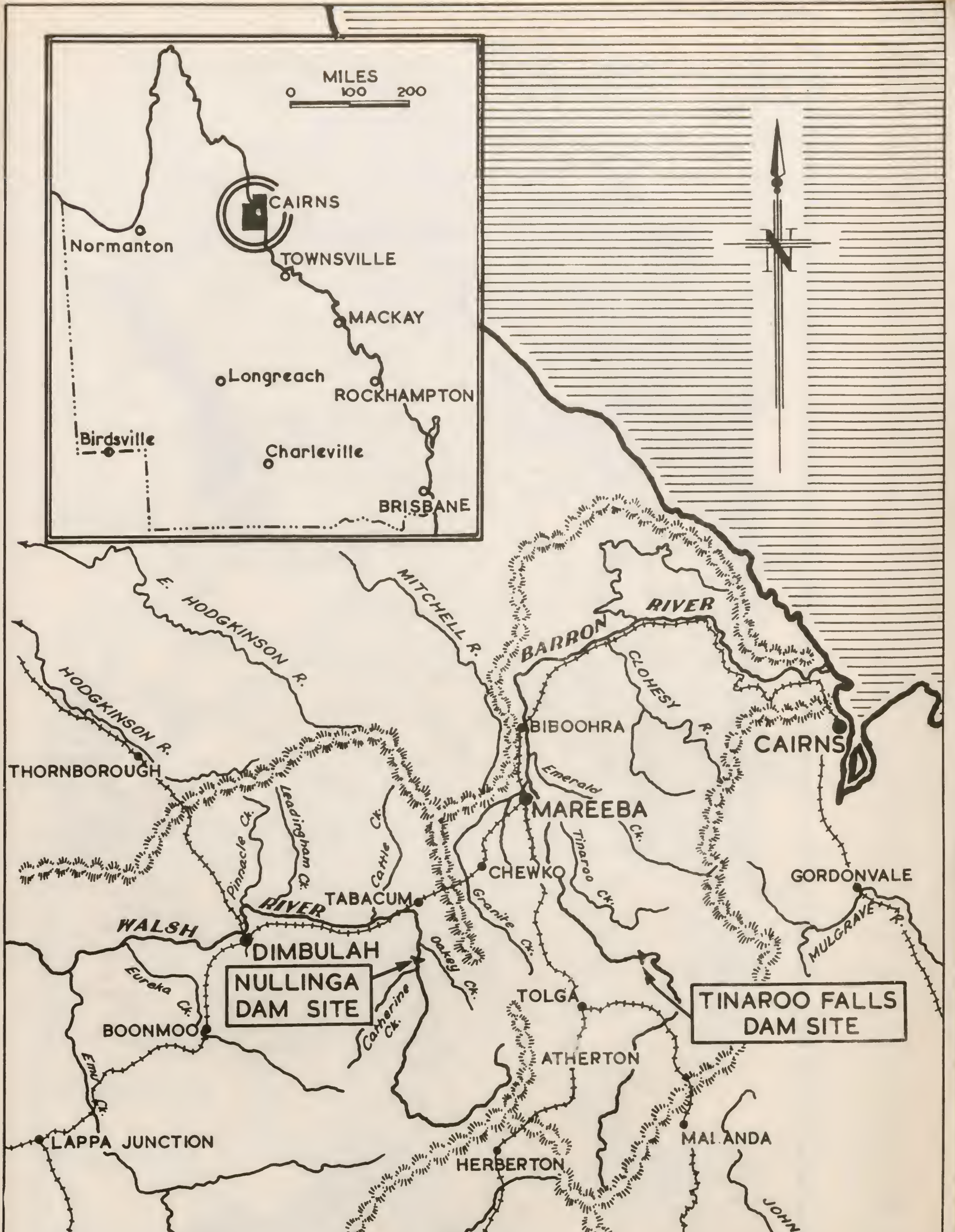
A request was made by the Irrigation Commission for a rapid survey of the lands adjacent to the Clohesy River for tobacco production. A one-day inspection by Messrs. Steele and Baird (Department of Agriculture and Stock) and Skerman was made and it was found that these soils are particularly attractive and could be classed in Types 2, 4 and 5 of the Mareeba-Dimbulah areas. The gross areas of the three types are outlined on the tentative soil map, and are respectively 1,480 acres, 710 acres and 500 acres or a total of 2,690 acres. All are suitable for tobacco growing and general cropping. We were told that the leaf of the Clohesy River area was of poor aroma and buyers were not keen to purchase the leaf. It is difficult to assess why this should be so as the soils appear most attractive.

P. J. SKERMAN,
Agricultural Resources Officer.

G. H. ALLEN,
Technical Officer.

12th December, 1950.

By Authority: A. H. Tucker, Government Printer, Brisbane.



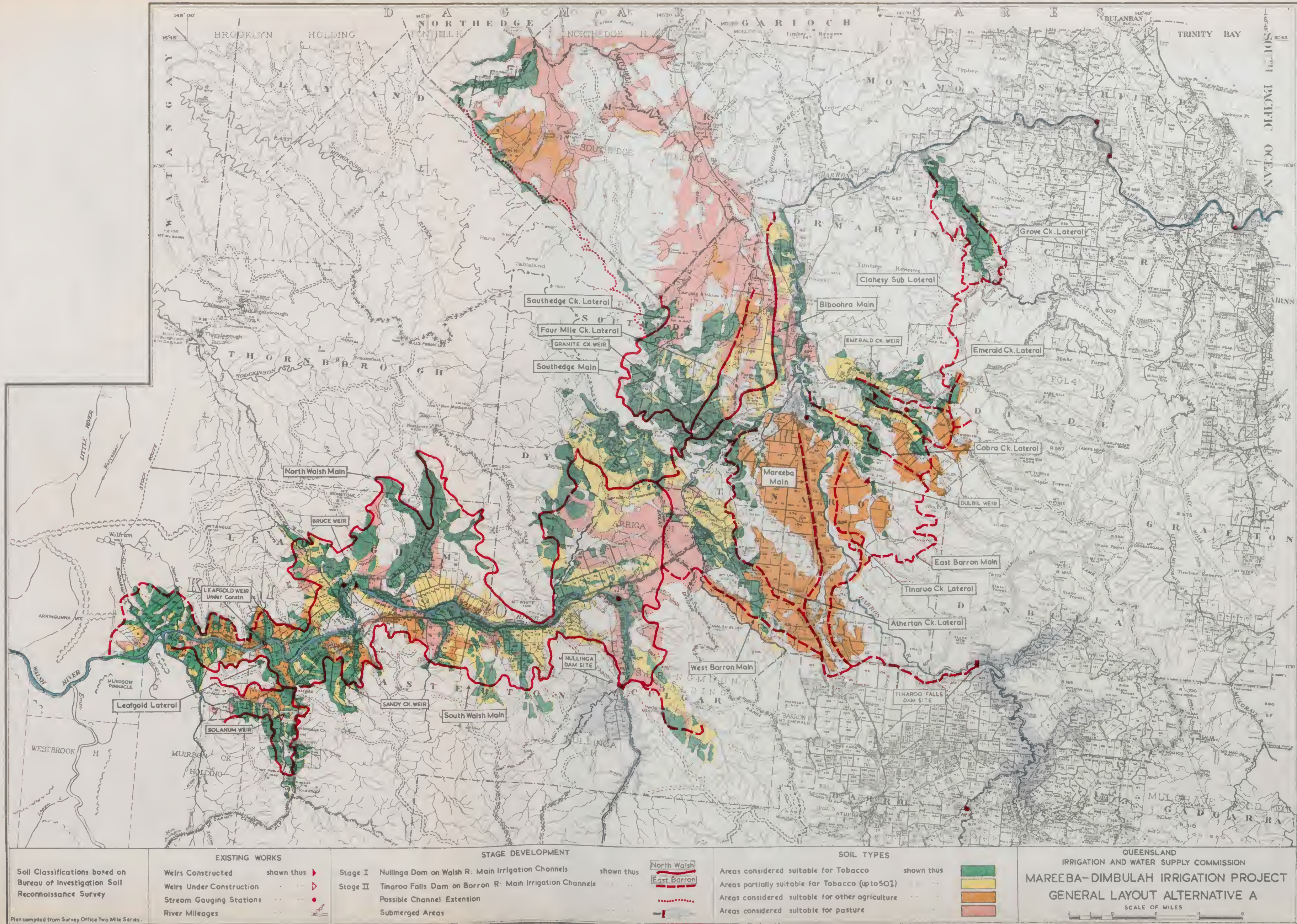
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

LOCALITY PLAN

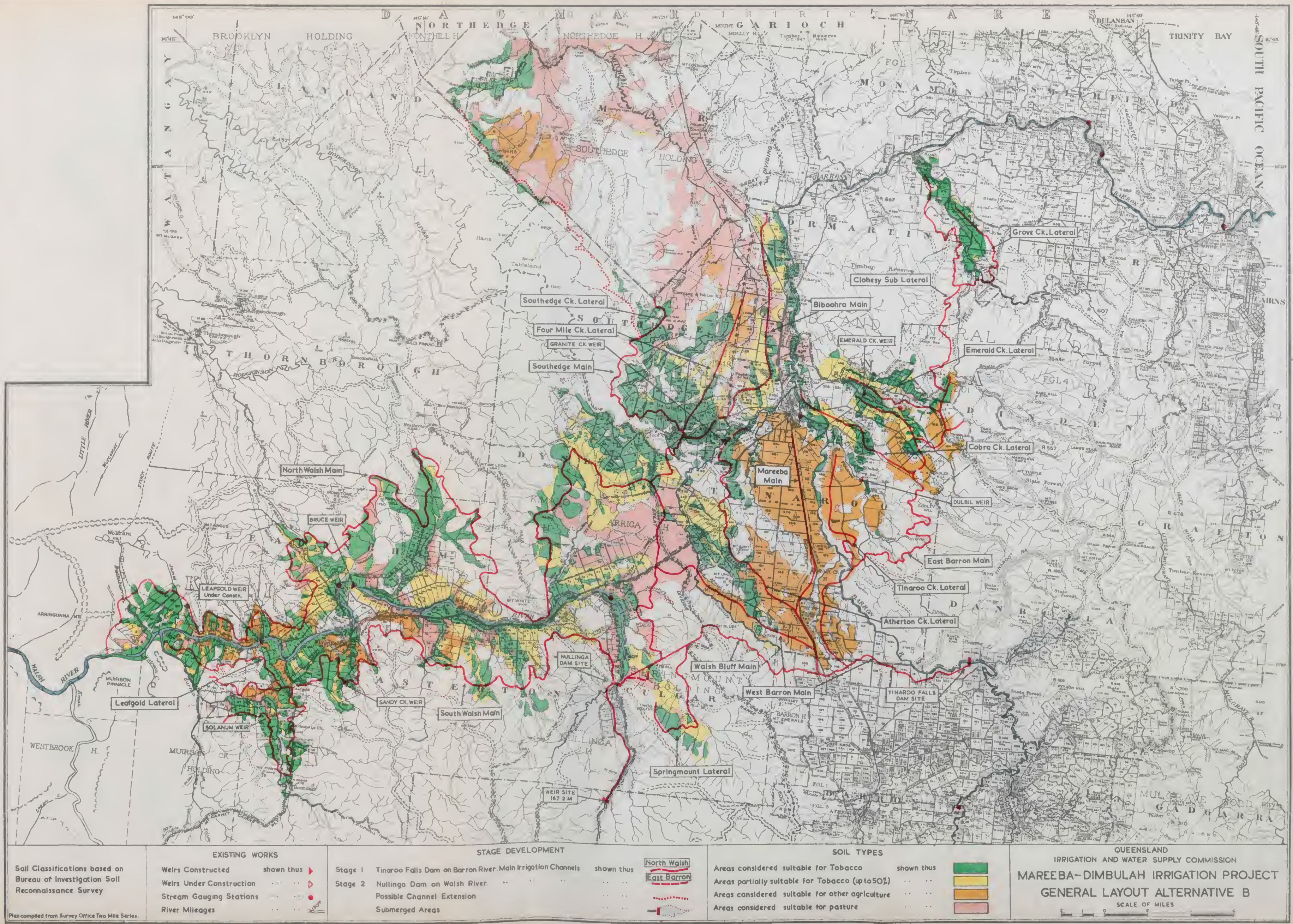
SCALE OF MILES
4 0 4 8 12

FIG. I



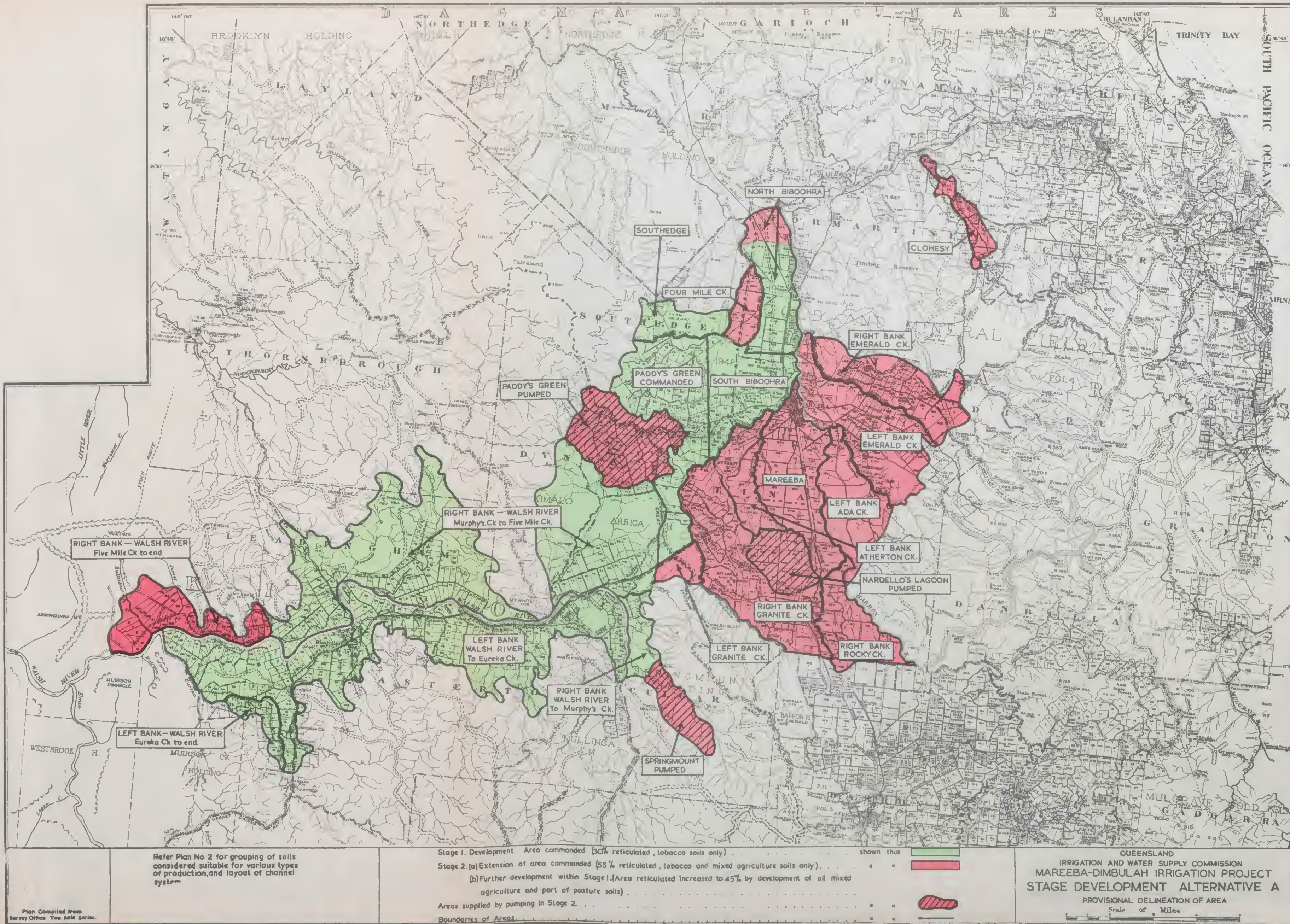
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA–DIMBULAH IRRIGATION PROJECT
GENERAL LAYOUT ALTERNATIVE A
SCALE OF MILES
Soil Classifications based on Bureau of Investigation Soil Reconnaissance Survey
Plan compiled from Survey Office Two Mile Series.
EXISTING WORKS
Weirs Constructed shown thus
Weirs Under Construction
Stream Gauging Stations
River Mileages
STAGE DEVELOPMENT
Stage I Nullinga Dam on Walsh R: Main Irrigation Channels shown thus North Walsh
Stage II Tinaroo Falls Dam on Barron R: Main Irrigation Channels East Barron
Possible Channel Extension
Submerged Areas
SOIL TYPES
Areas considered suitable for Tobacco shown thus
Areas partially suitable for Tobacco (up to 50%)
Areas considered suitable for other agriculture
Areas considered suitable for pasture
Grove Ck. Lateral
Clahesy Sub Lateral
Biboohra Main
Southedge Ck. Lateral
Four Mile Ck. Lateral
GRANITE CK. WEIR
Southedge Main
EMERALD CK. WEIR
Emerald Ck. Lateral
Cobra Ck. Lateral
Mareeba Main
DULBIL WEIR
East Barron Main
Tinaroo Ck. Lateral
Atherton Ck. Lateral
West Barron Main
TINAROO FALLS DAM SITE
North Walsh Main
BRUCE WEIR
LEAFGOLD WEIR Under Constn.
NULLINGA DAM SITE
SANDY CK. WEIR
South Walsh Main
Leafgold Lateral
SOLANUM WEIR
WALSH RIVER
TRINITY BAY
SOUTH PACIFIC OCEAN
CAIRNS
BARRON R.

FIG. 2



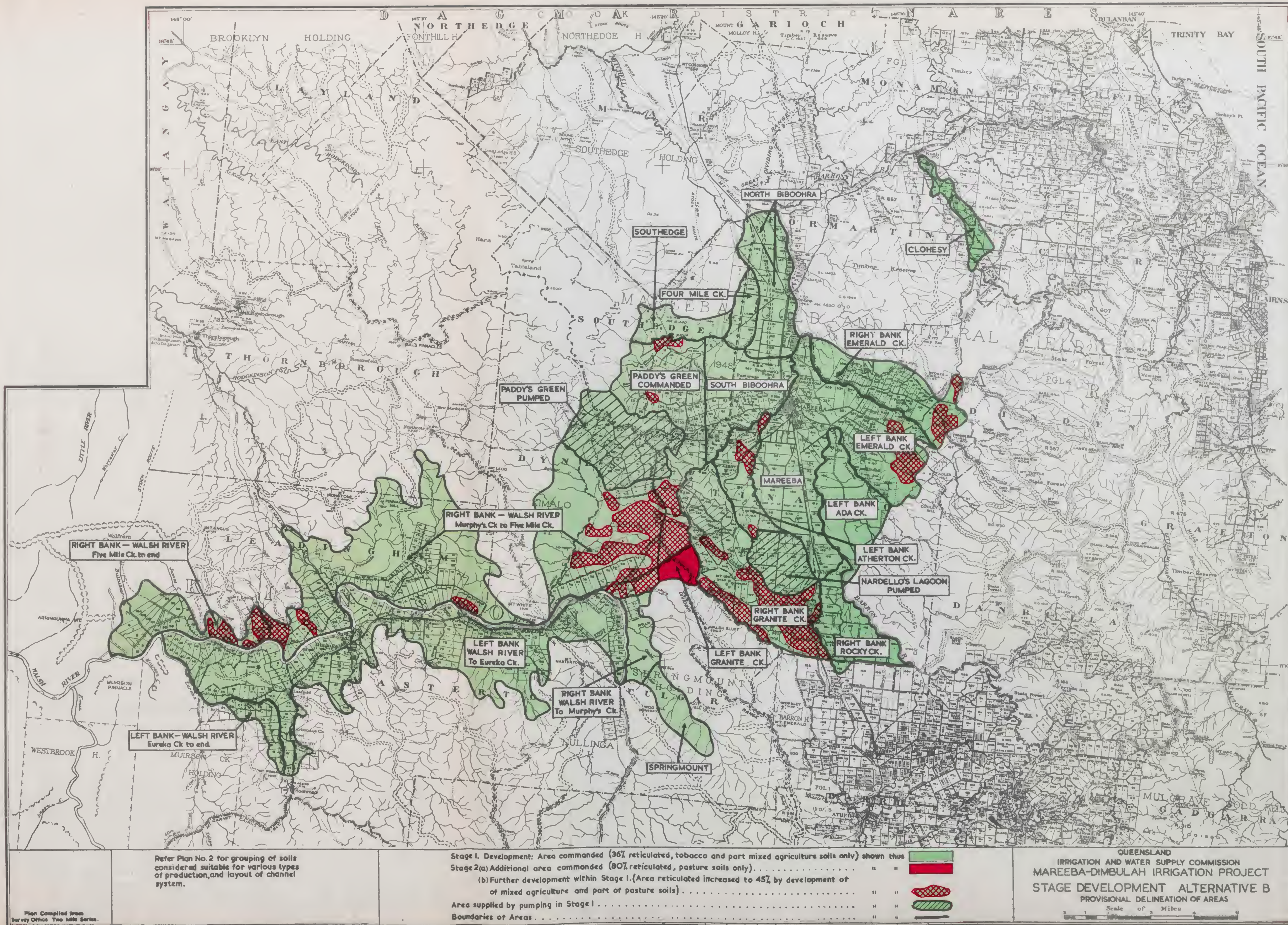
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA-DIMBULAH IRRIGATION PROJECT
GENERAL LAYOUT ALTERNATIVE B
SCALE OF MILES
Soil Classifications based on Bureau of Investigation Soil Reconnaissance Survey
Plan compiled from Survey Office Two Mile Series.
EXISTING WORKS
Weirs Constructed shown thus
Weirs Under Construction
Stream Gauging Stations
River Mileages
STAGE DEVELOPMENT
Stage 1 Tinaroo Falls Dam on Barron River. Main Irrigation Channels shown thus
Stage 2 Nullinga Dam on Walsh River.
Possible Channel Extension
Submerged Areas
North Walsh
East Barron
SOIL TYPES
Areas considered suitable for Tobacco shown thus
Areas partially suitable for Tobacco (up to 50%)
Areas considered suitable for other agriculture
Areas considered suitable for pasture
TRINITY BAY
SOUTH PACIFIC OCEAN
CAIRNS
Grove Ck. Lateral
Clohesy Sub Lateral
Biboohra Main
Southedge Ck. Lateral
Four Mile Ck. Lateral
GRANITE CK. WEIR
Southedge Main
EMERALD CK. WEIR
Emerald Ck. Lateral
Cobra Ck. Lateral
Mareeba Main
DULBIL WEIR
East Barron Main
Tinaroo Ck. Lateral
Atherton Ck. Lateral
North Walsh Main
BRUCE WEIR
LEAFGOLD WEIR Under Constn.
Leafgold Lateral
SOLANUM WEIR
SANDY CK. WEIR
South Walsh Main
NULLINGA DAM SITE
Walsh Bluff Main
West Barron Main
TINAROO FALLS DAM SITE
Springmount Lateral
WEIR SITE 167.2 M
WALSH RIVER

FIG. 3



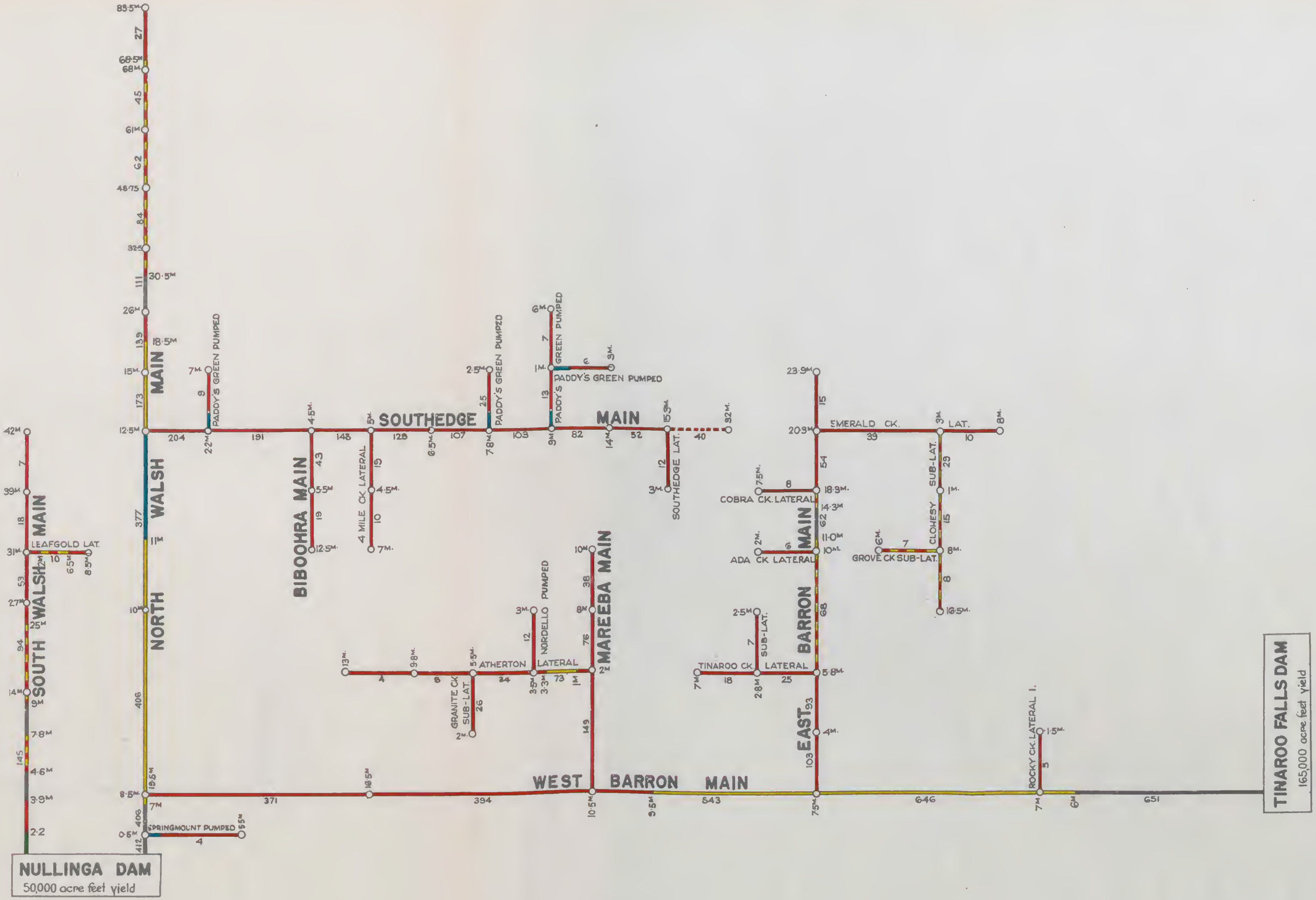
TRINITY BAY
SOUTH PACIFIC OCEAN
CAIRNS
NORTH BIBOOHRA
SOUTHEDGE
CLOHESY
FOUR MILE CK.
RIGHT BANK EMERALD CK.
PADDY'S GREEN PUMPED
PADDY'S GREEN COMMANDED
SOUTH BIBOOHRA
LEFT BANK EMERALD CK.
MAREEBA
LEFT BANK ADA CK.
RIGHT BANK — WALSH RIVER Murphy's Ck to Five Mile Ck.
RIGHT BANK — WALSH RIVER Five Mile Ck. to end
LEFT BANK ATHERTON CK.
NARDELLO'S LAGOON PUMPED
RIGHT BANK GRANITE CK.
RIGHT BANK ROCKY CK.
LEFT BANK WALSH RIVER To Eureka Ck.
LEFT BANK GRANITE CK.
RIGHT BANK WALSH RIVER To Murphy's Ck.
LEFT BANK — WALSH RIVER Eureka Ck to end
SPRINGMOUNT PUMPED
Plan Compiled from Survey Office Two Mile Series.
Refer Plan No. 2 for grouping of soils considered suitable for various types of production, and layout of channel system
Stage I. Development Area commanded (30% reticulated, tobacco soils only) . . . shown thus
Stage 2. (a) Extension of area commanded (55% reticulated, tobacco and mixed agriculture soils only) . . .
(b) Further development within Stage I. (Area reticulated increased to 45% by development of all mixed agriculture and part of pasture soils) . . .
Areas supplied by pumping in Stage 2. . . .
Boundaries of Areas . . .
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA-DIMBULAH IRRIGATION PROJECT
STAGE DEVELOPMENT ALTERNATIVE A
PROVISIONAL DELINEATION OF AREA
Scale of Miles

FIG. 4



QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA-DIMBULAH IRRIGATION PROJECT
STAGE DEVELOPMENT ALTERNATIVE B
PROVISIONAL DELINEATION OF AREAS
Scale of Miles
Refer Plan No. 2 for grouping of soils considered suitable for various types of production, and layout of channel system.
Plan Compiled from Survey Office Two Mile Series.
Stage I. Development: Area commanded (36% reticulated, tobacco and part mixed agriculture soils only) shown thus
Stage 2(a) Additional area commanded (80% reticulated, pasture soils only) " "
(b) Further development within Stage I. (Area reticulated increased to 45% by development of of mixed agriculture and part of pasture soils) " "
Area supplied by pumping in Stage I " "
Boundaries of Areas " "
NORTH BIBOOHRA
SOUTHEDGE
FOUR MILE CK.
CLOHESY
RIGHT BANK EMERALD CK.
PADDY'S GREEN COMMANDED
SOUTH BIBOOHRA
PADDY'S GREEN PUMPED
LEFT BANK EMERALD CK.
MAREEBA
LEFT BANK ADA CK.
LEFT BANK ATHERTON CK.
NARDELLO'S LAGOON PUMPED
RIGHT BANK — WALSH RIVER Murphy's Ck to Five Mile Ck.
RIGHT BANK — WALSH RIVER Five Mile Ck. to end
RIGHT BANK GRANITE CK.
RIGHT BANK ROCKY CK.
LEFT BANK GRANITE CK.
LEFT BANK WALSH RIVER To Eureka Ck.
RIGHT BANK WALSH RIVER To Murphy's Ck.
LEFT BANK—WALSH RIVER Eureka Ck to end.
SPRINGMOUNT
SOUTH PACIFIC OCEAN
TRINITY BAY
CAIRNS

FIG. 5

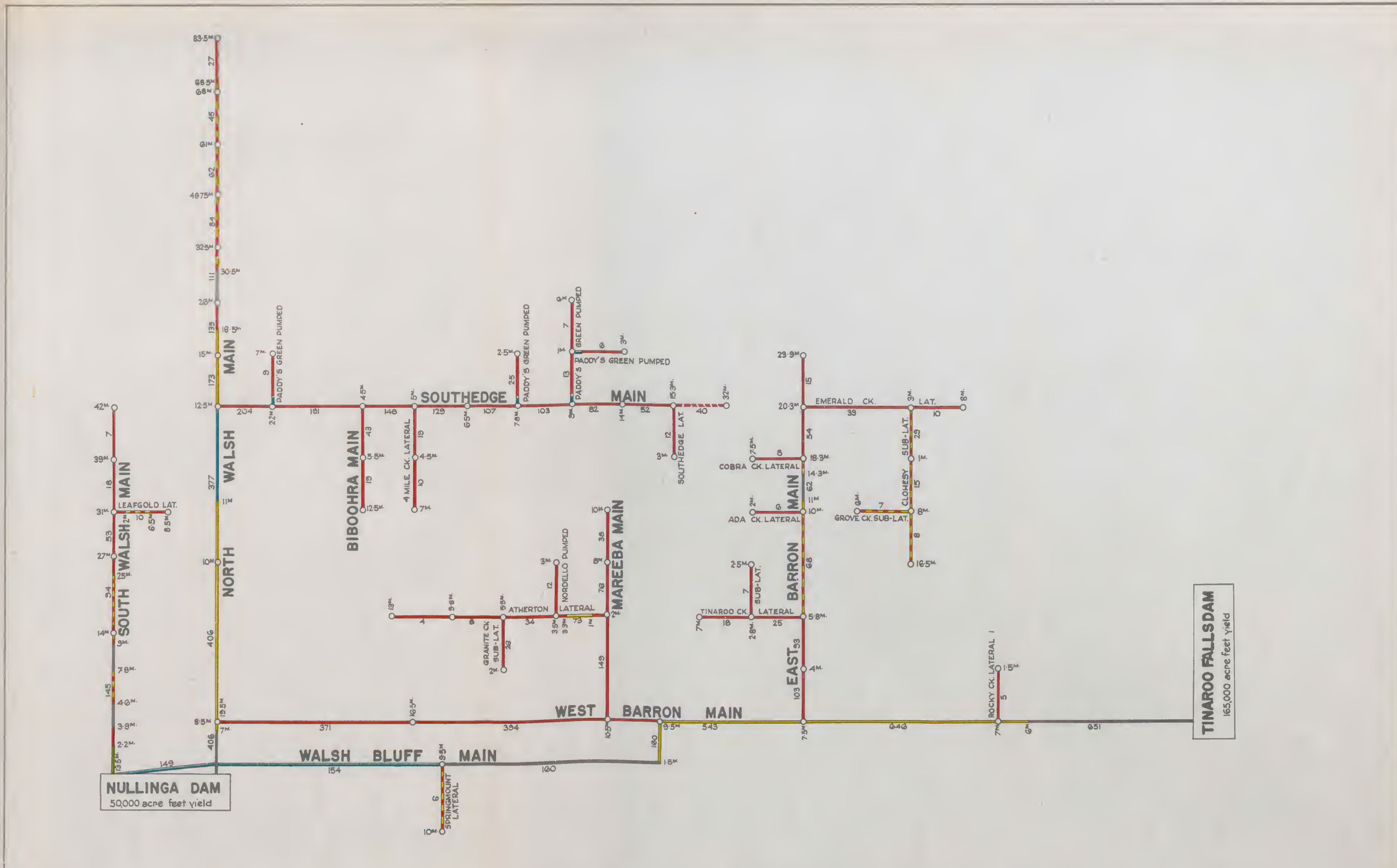


Earth Channel	shown thus	Mileages at changes in Channel Capacity	shown thus
Clay lined Channel	.. ..	Mileages at changes in Channel Type	.. ..
50% Earth 50% Concrete lined Channel	.. ..	Channel Capacity in Cubic Feet per Second	.. ..
Concrete lined Channel	.. ..	Possible Future Extension	
Concrete Bench Flume	.. ..		
Pipe			

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT
LINE DIAGRAM OF MAIN CHANNEL CAPACITIES
ALTERNATIVE A

FIG 6



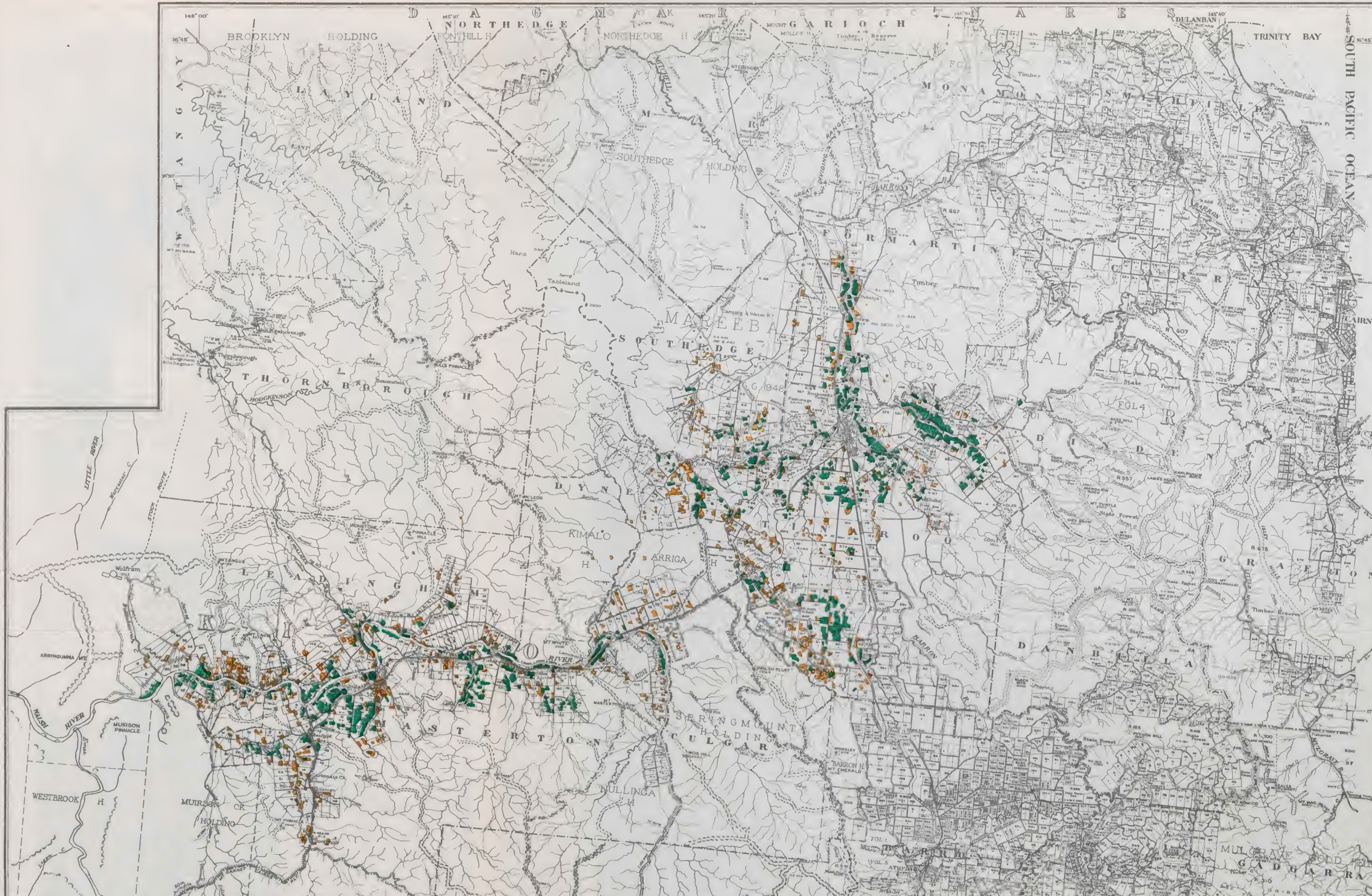
Earth Channel	shown thus
Clay lined Channel	.. ..
50% Earth 50% Concrete lined Channel	.. ..
Concrete lined Channel	.. ..
Concrete Bench Flume	.. ..
Pipe	.. ..

Mileages at changes in Channel Capacity	shown thus
Mileages at changes in Channel Type	.. ..
Channel Capacity in Cubic Feet per Second	 646
Possible Future Extension	.. ..

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT
LINE DIAGRAM OF MAIN CHANNEL CAPACITIES
ALTERNATIVE B

FIG 7



Land use determined by Bureau of Investigation, from Field Observation and Aerial Photographs.

Plan Compiled from Survey Office Two Mile Series.

Land at present under cultivation (mainly for tobacco) shown thus

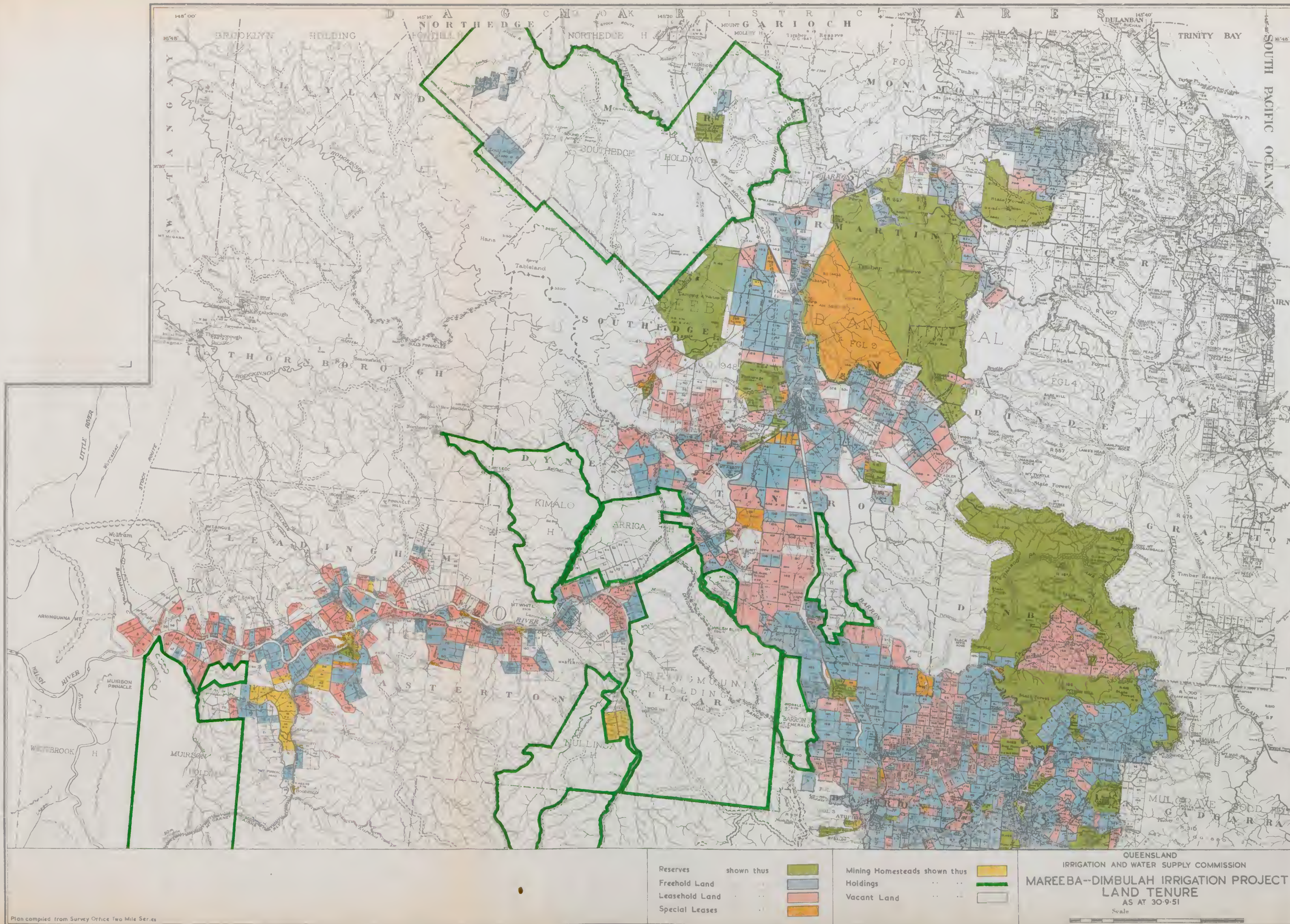
Land formerly under cultivation shown thus

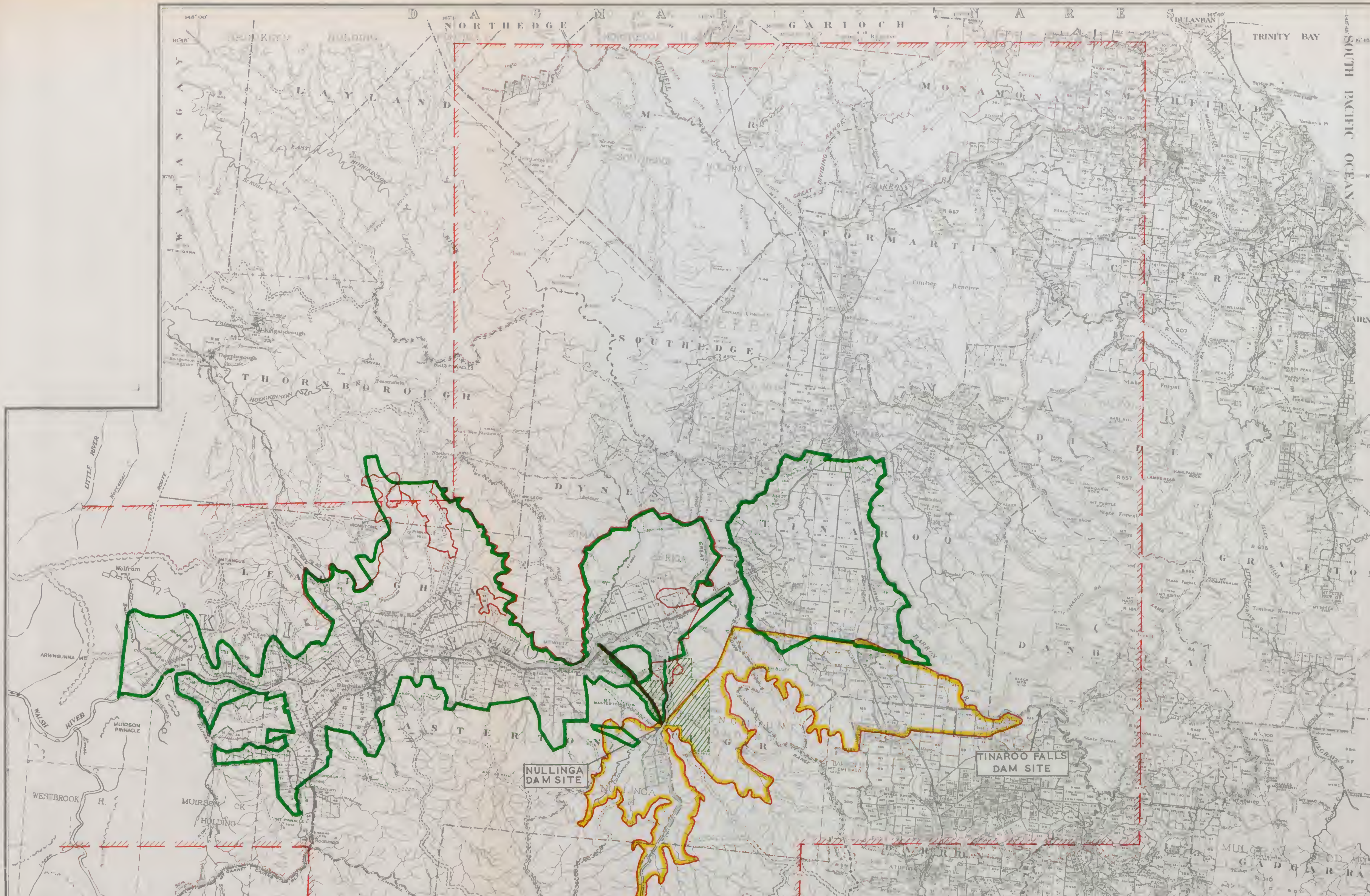
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA–DIMBULAH IRRIGATION PROJECT
AGRICULTURAL DEVELOPMENT
AS AT 30·9·51

SCALE OF MILES

FIG. 8


Reserves shown thus
Freehold Land
Leasehold Land
Special Leases
Mining Homesteads shown thus
Holdings
Vacant Land
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA--DIMBULAH IRRIGATION PROJECT
LAND TENURE
AS AT 30·9·51
Scale
Plan compiled from Survey Office Two Mile Series
SOUTH PACIFIC OCEAN
TRINITY BAY
CAIRNS
FGL 9
FGL 4
KIMALO
ARRIGA
NULLINGA
MUIRSON
WESTBROOK
FIG 9



Boundary of Area covered by Five-foot Contour Survey	shown thus		Boundary of Area covered by Aerial Photography	shown thus
" " " One-foot " "	" "		Boundary of Area covered by Multiplex Plot from Aerial and Ground Control Surveys – Nullinga Storage Survey and Barron – Walsh System	shown thus
Channel Line Location Survey	" "			
Nullinga Dam Access Road Survey	" "			

Note: Survey Progress shown as at 30·9·51

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA–DIMBULAH IRRIGATION PROJECT
SURVEY PROGRESS
AS AT 30·9·51

Scale of Miles

Plan Compiled from Survey Office Two Mile Series

FIG 10

SCALE

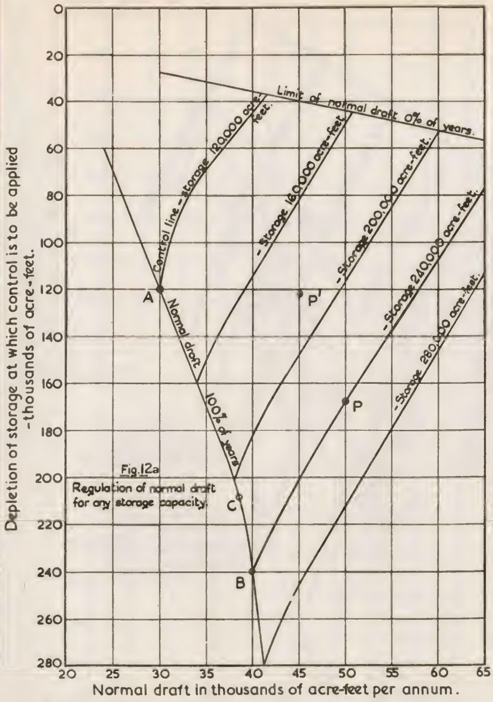
Miles. 6 5 4 3 2 1 0 — 6 — 12 — 18 Miles.

Rainfall Stations shown thus :- ■ BARRON

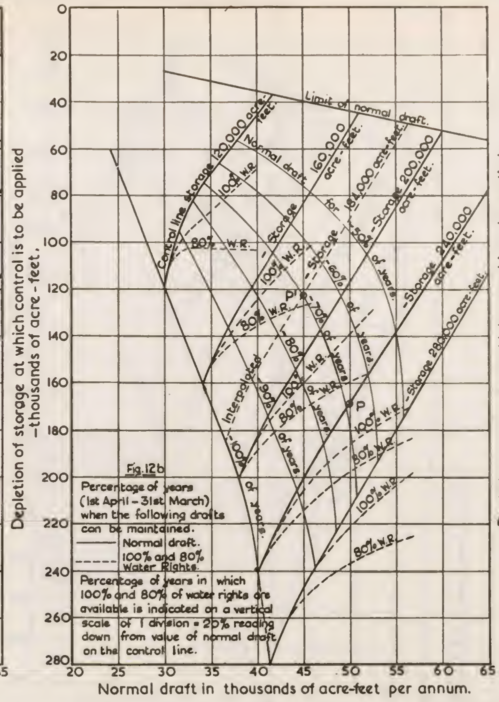
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA — DIMBULAH IRRIGATION PROJECT
BARRON RIVER AND UPPER WALSH RIVER CATCHMENTS

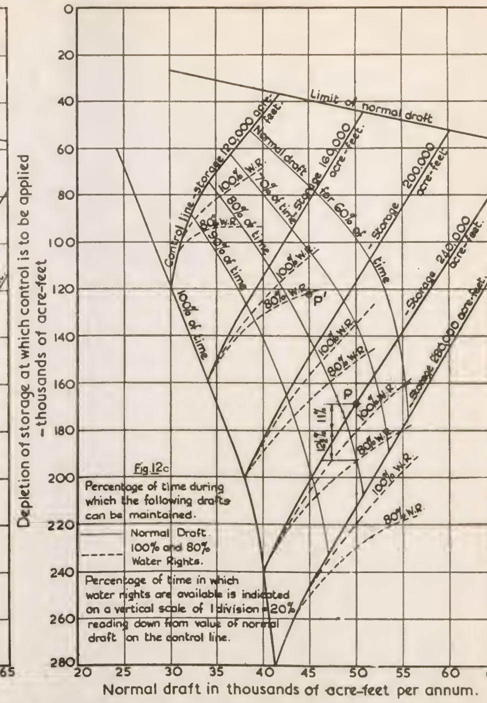
ISOHYETAL MAP



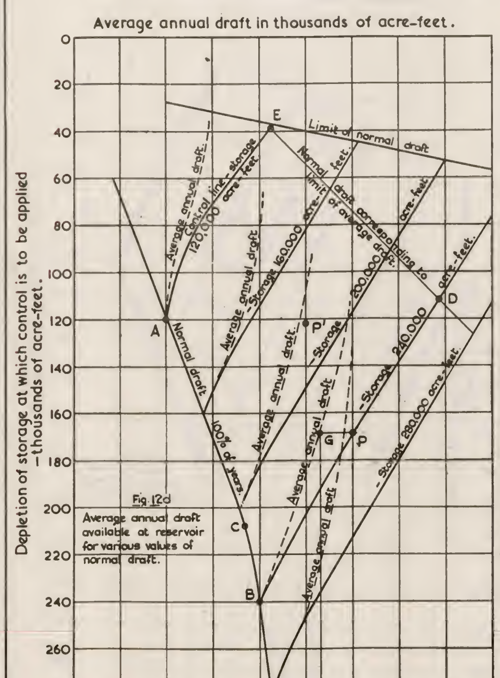
Control lines are drawn for five reservoir capacities and indicate the stage at which variation from normal draft should be applied.
Example:- Reservoir capacity 240,000 acre-feet, normal draft 50,000 acre-feet per annum, point P on diagram. Control is to be applied when volume of stored water has fallen 168,000 acre-feet below full supply. Other control lines may be interpolated.



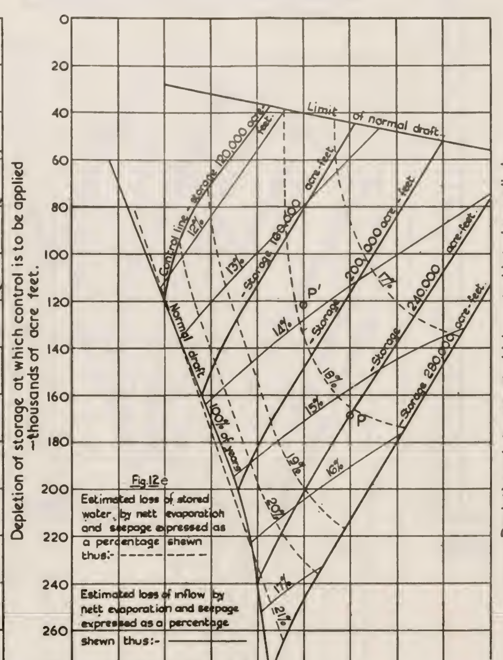
The curved lines crossing the control lines indicate the percentage of years (1st April - 31st March) throughout which normal draft can be maintained.
Example:- Reservoir capacity 240,000 acre-feet, 50,000 acre-feet normal draft can be maintained 69% of years, (see point P on diagram.)



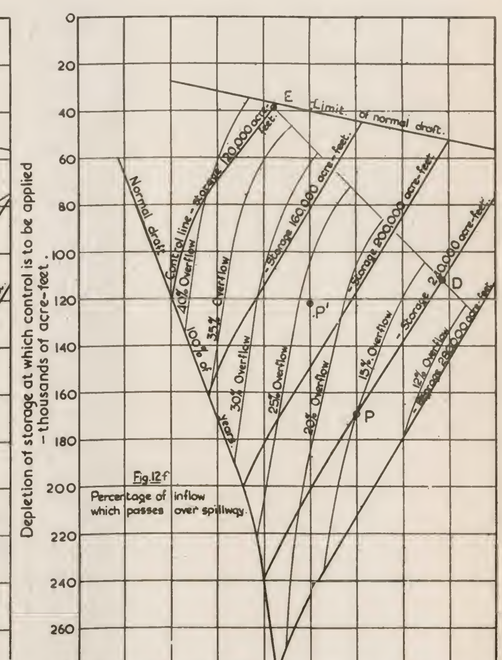
This figure shows the percentage of time in which -
(a) Normal draft can be maintained.
(b) Supply is reduced to 100% water rights.
(c) Supply is reduced to 80% water rights.
Example:- At point P normal draft is available 76½% of time, 100% water rights 11% of time, and 80% water rights 12½% of time.



Regulation of draft results in availability of a greater average yield or draft. Broken lines in the figure indicate the average draft corresponding to a normal draft. Example:- From point P run horizontally to G on an average annual draft line and the average draft corresponding to a normal draft of 50,000 acre-feet is 46,200. Note! This is 6,200 greater than the normal draft available for 100% of years (40,000 acre-feet) point B on diagram. The normal draft corresponding to the maximum obtainable yield (Average annual draft) is shown on diagram by the line D. E.



Nett evaporation is the difference between evaporation from and rainfall on the varying submerged area of storage.
Seepage losses have been assumed at two feet per annum on the varying submerged area.
Example:- At point P losses are 15·3% of inflow and 17·9% of water stored for irrigation. (Inflow less overflow.)

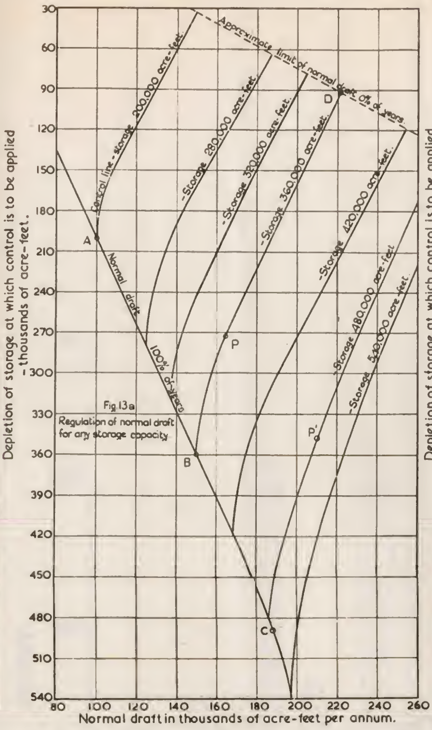


This figure shows the overflow expressed as a percentage of inflow.
Example:- At point P overflow is 15% of inflow.

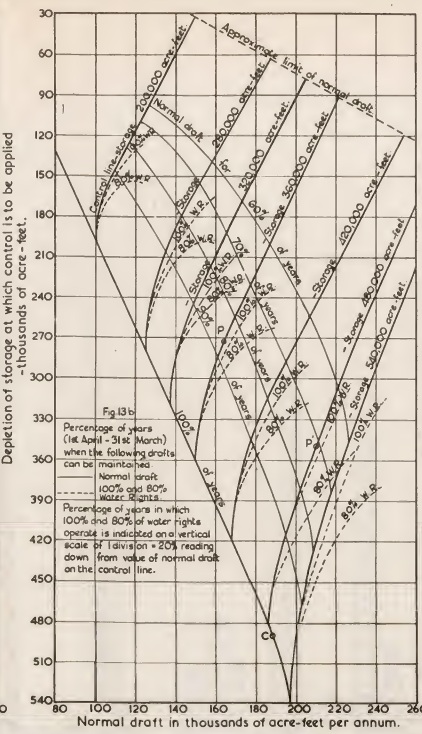
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT
NULLINGA STORAGE
HYDROLOGIC ANALYSIS

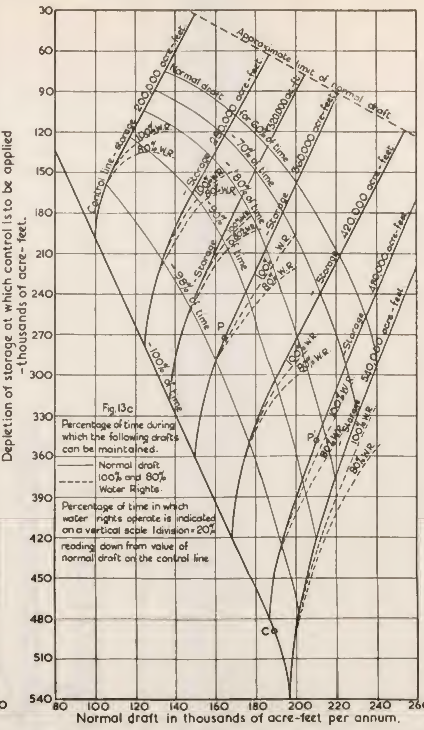
FIG.12



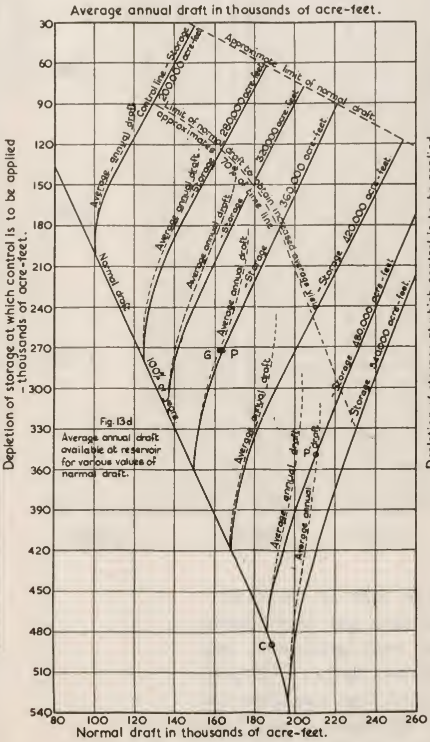
Control lines are drawn for 7 reservoir capacities. They indicate the stage at which variation from normal draft should be applied.
Example:- Reservoir capacity 360,000 acre-feet, normal draft 165,000 acre-feet per annum. The line B.P.D. represents the control line for 360,000 acre-feet storage. The point P on the intersection of draft and control lines gives a value of 273,000 acre-feet below full supply as the stage where control is to be applied. Other control lines may be interpolated.



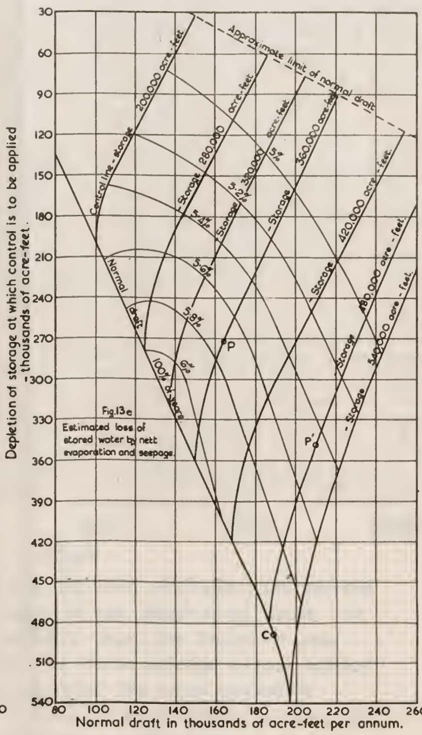
The curved lines indicate the percentage of water years throughout which normal draft can be maintained.
Example:- As in Fig. 1. point P on diagram.
A normal draft of 165,000 acre-feet per annum can be maintained 85% of water years (1st April - 31st March)



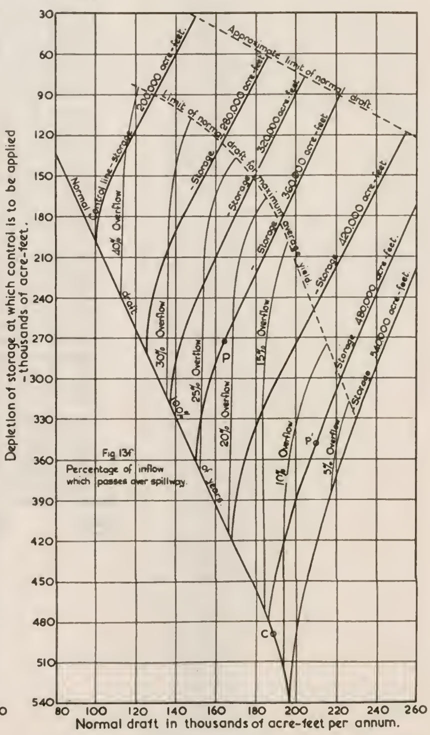
This figure shows the percentage of time in which:-
(a) Normal draft can be maintained.
(b) Supply is reduced to 100% water rights
(c) Supply is reduced to 80% water rights.
Example:- At point P normal draft can be maintained for 95% of time, 100% water rights for 3% of time and 80% water rights for 2% of time.



Moderate regulation of draft results in availability of a greater average draft (yield) The broken lines in the figure indicate the average draft by reading horizontally from the normal draft. Example:- From point P run horizontally to G on an average annual draft line and the average draft corresponding to a normal draft of 165,000 acre-feet is 162,500 acre-feet. Note! this is 12,500 greater than the normal draft available for 100% of years (150,000 acre-feet). The limit of gain is reached when the average annual draft curve becomes tangential to a vertical draft line.



Nett evaporation is the difference between evaporation from and rainfall on the varying submerged area of storage. Seepage losses have been assumed at two feet per annum on the same area.
Example:- At point P losses are 5·7% of water stored for irrigation and hydro-electric use. (Inflow less overflow)

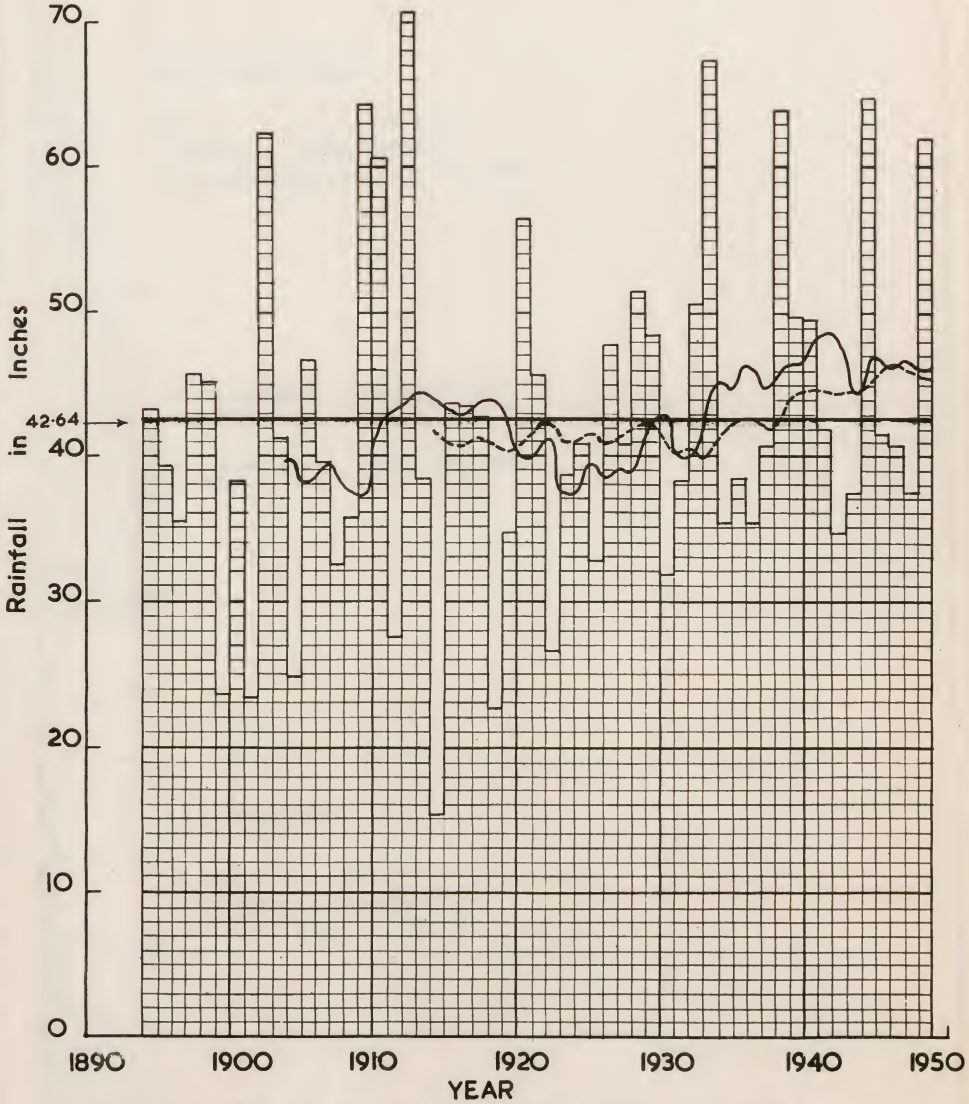


During flood flows a percentage of inflow passes over the spillway.
Example:- At point P there is 21% over-flow (interpolated).

QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT
TINAROO STORAGE
HYDROLOGIC ANALYSIS

FIG. 13



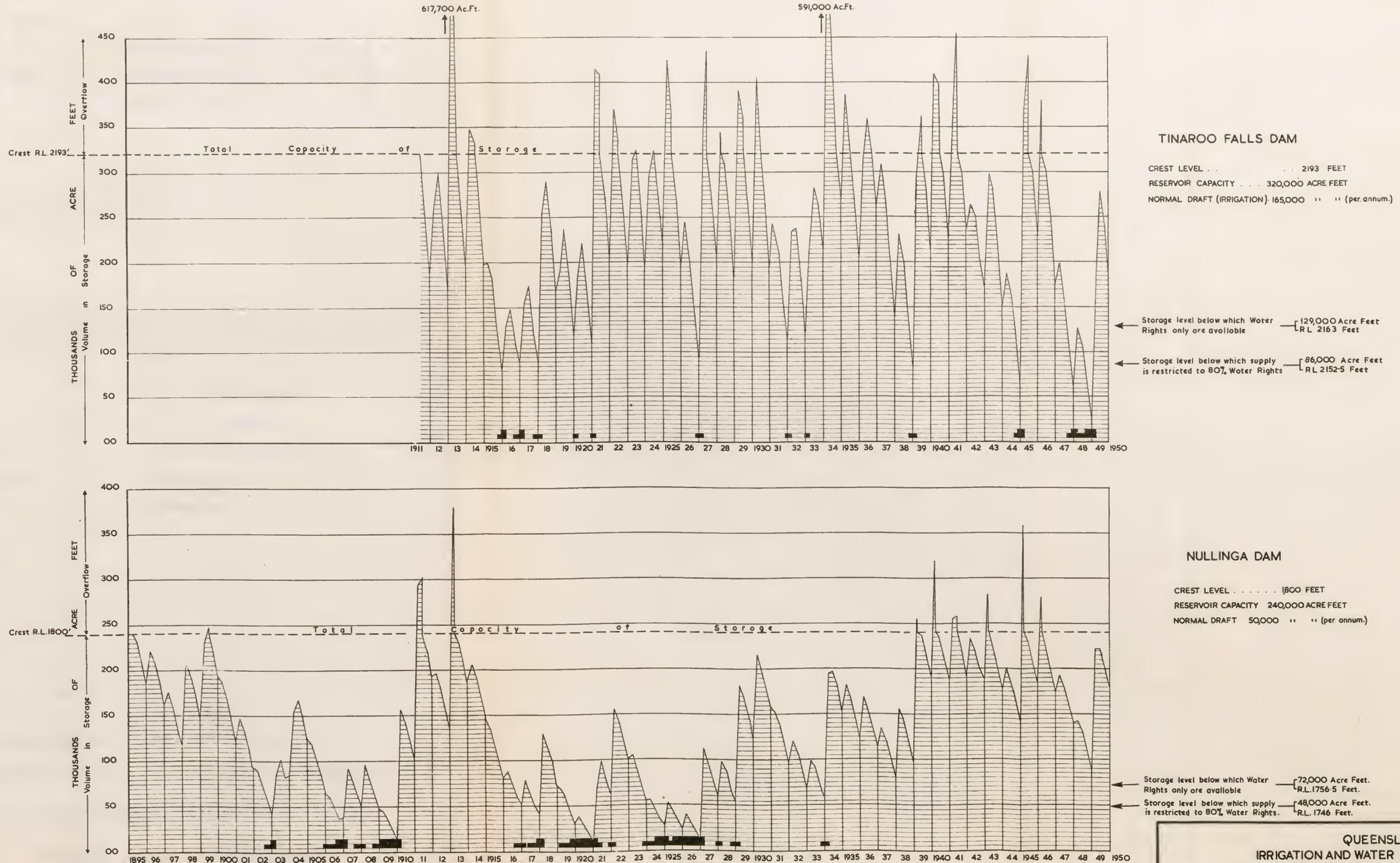
Over the 35 year period 1915–1949, inclusive, the average rainfall over the catchment of the Walsh River above the site of Nullinga Dam obtained from the Isohyetal Map (Fig. 11) is 42·64 inches. The mean average annual rainfall at Herberton and Atherton over the same period is 48·83 inches. Average rainfall on the catchment for each year from 1895 to 1949 was obtained by multiplying the mean value for Herberton and Atherton by the ratio $\frac{42 \cdot 64}{48 \cdot 83} = 0 \cdot 873$.

Average Rainfall ———	QUEENSLAND
10 Year Average ~~	IRRIGATION AND WATER SUPPLY COMMISSION
20 Year Average - - -	MAREEBA–DIMBULAH IRRIGATION PROJECT

ANNUAL RAINFALL

WALSH RIVER CATCHMENT ABOVE NULLINGA

FIG. 14



Periods during which Water Rights only are available shown thus

Periods during which supply is restricted to 80% Water Rights " "

At all other times 130% Water Rights are available

(i.e. Water Right + 30% Sales.)

QUEENSLAND

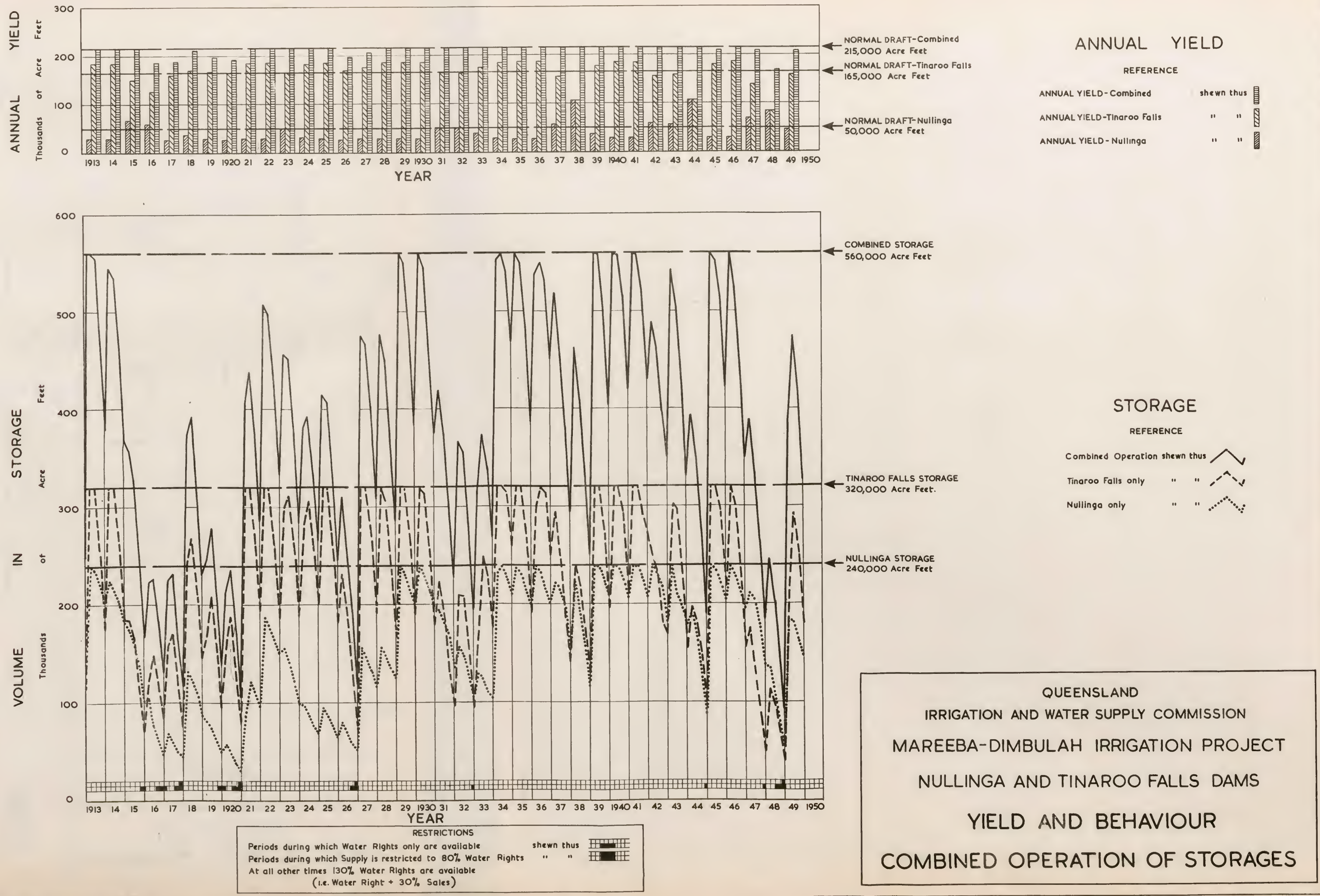
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

TINAROO FALLS AND NULLINGA DAMS

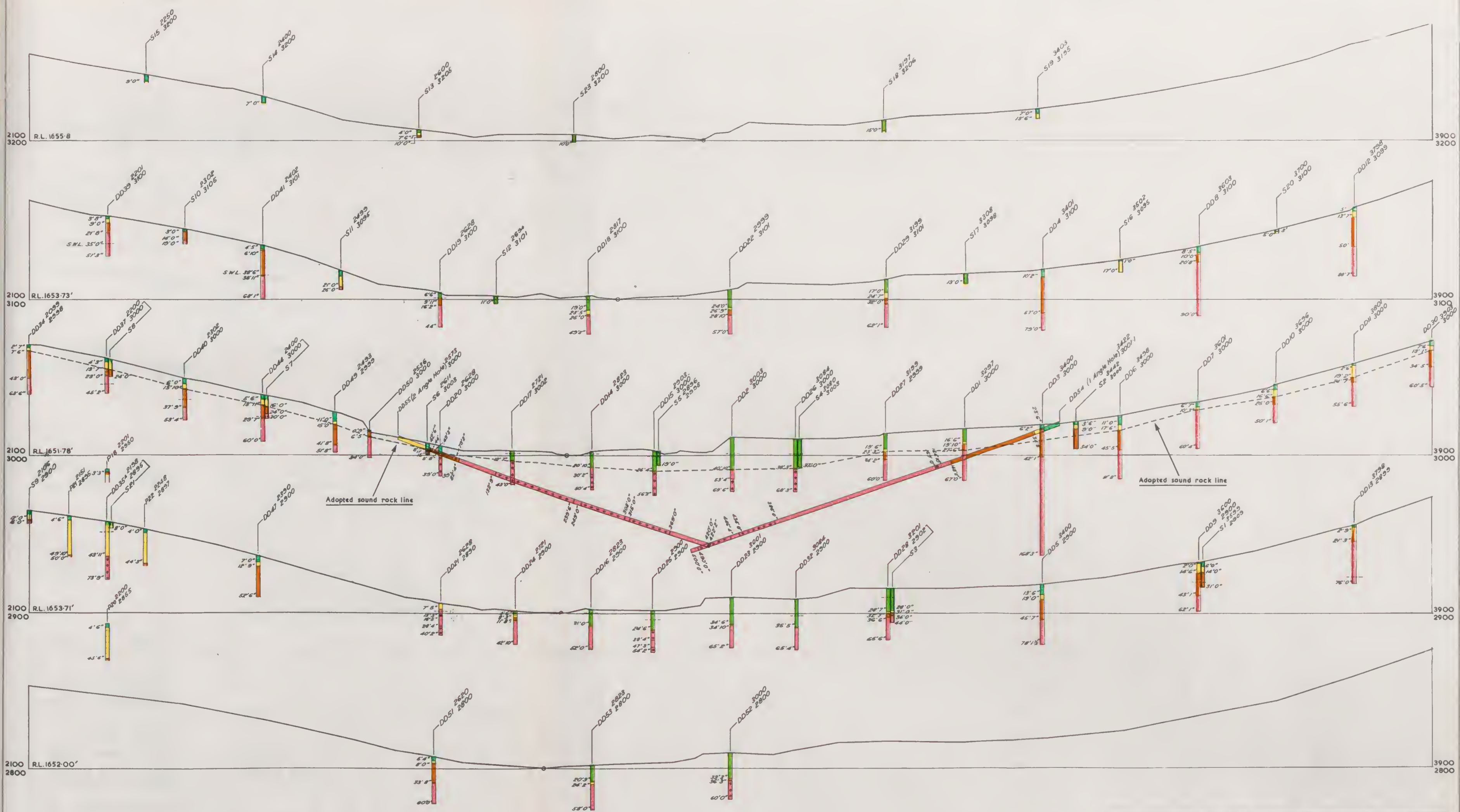
BEHAVIOUR DIAGRAMS FOR PROPOSED STORAGES

FIG. 15



ANNUAL YIELD Thousands of Acre Feet
YEAR
NORMAL DRAFT-Combined 215,000 Acre Feet
NORMAL DRAFT-Tinaroo Falls 165,000 Acre Feet
NORMAL DRAFT-Nullinga 50,000 Acre Feet
ANNUAL YIELD
REFERENCE
ANNUAL YIELD-Combined shewn thus
ANNUAL YIELD-Tinaroo Falls " "
ANNUAL YIELD-Nullinga " "
VOLUME IN STORAGE Thousands of Acre Feet
COMBINED STORAGE 560,000 Acre Feet
TINAROO FALLS STORAGE 320,000 Acre Feet.
NULLINGA STORAGE 240,000 Acre Feet
STORAGE
REFERENCE
Combined Operation shewn thus
Tinaroo Falls only " "
Nullinga only " "
RESTRICTIONS
Periods during which Water Rights only are available shewn thus
Periods during which Supply is restricted to 80% Water Rights " "
At all other times 130% Water Rights are available
(i.e. Water Right + 30% Sales)
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA-DIMBULAH IRRIGATION PROJECT
NULLINGA AND TINAROO FALLS DAMS
YIELD AND BEHAVIOUR
COMBINED OPERATION OF STORAGES

FIG. 16



SCALE

Horizontal / Vertical: 50 0 50 100 150 200 250 feet

REFERENCE

Soil rubble etc.	shown thus	
River alluvium	"	"
Very weathered weak rock	"	"
Rock with some weathered joints	"	"
Sound rock (porphyry)	"	"
" " (granite)	"	"

NOTE - No distinction is made between the various types of porphyry

Diamond drill holes	shown thus	DD16
Percussion drill holes	" "	P
Shafts	" "	S17

NOTE: Sections Y2800 and Y3200 plotted from contours.

Levels Datum - State.

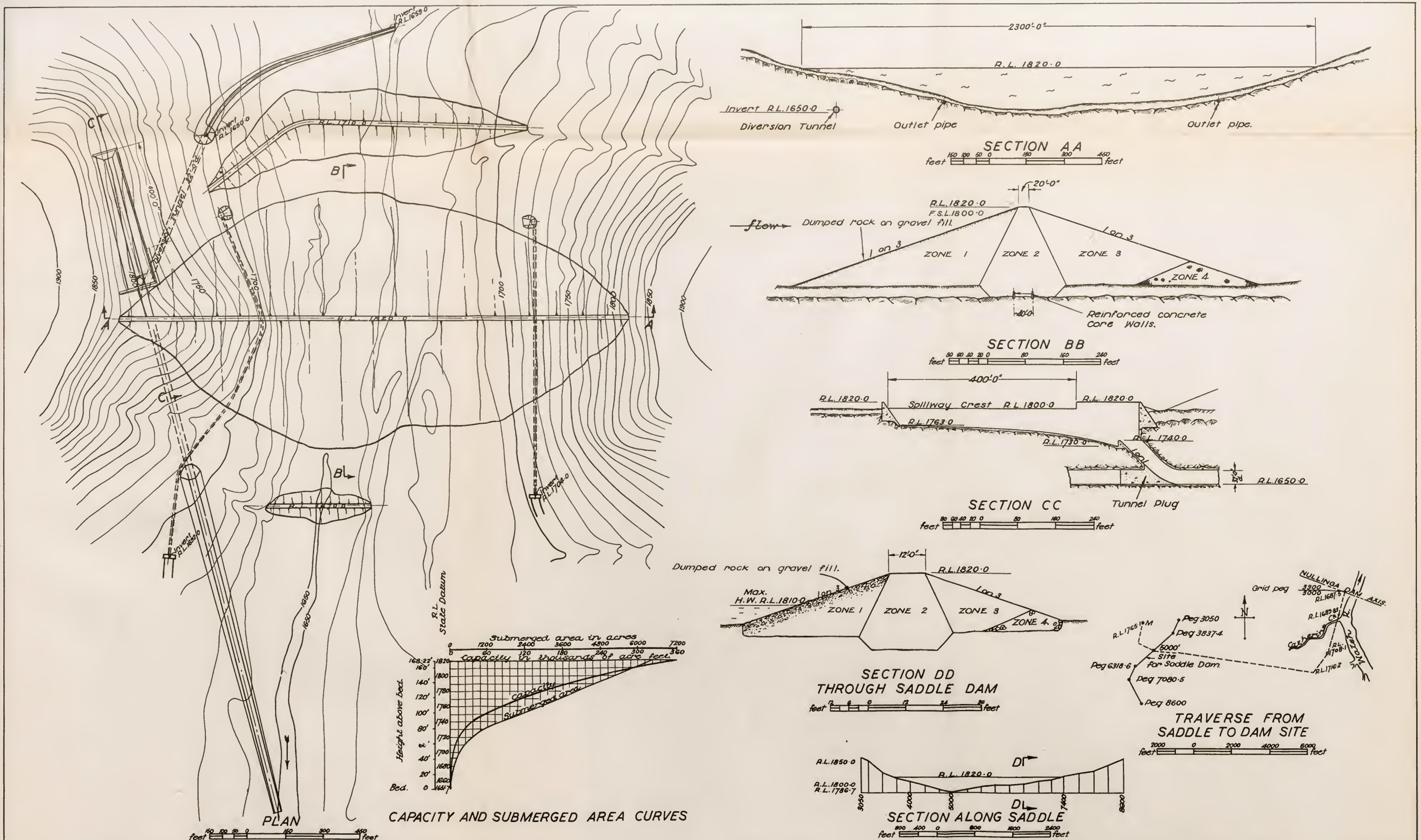
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA - DIMBULAH IRRIGATION PROJECT

NULLINGA DAM

FOUNDATION CROSS SECTIONS

FIG 17



QUEENSLAND

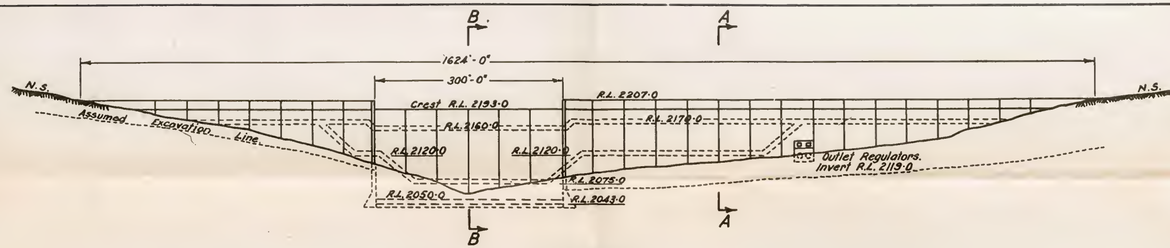
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

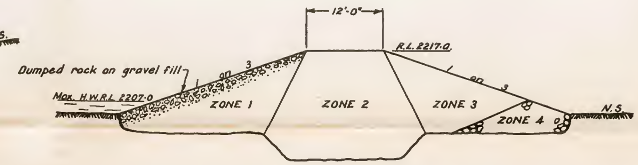
NULLINGA DAM, WALSH R. 161·3M.

PROPOSED EARTH FILL DAM. CREST RL.1800·0

FIG 18

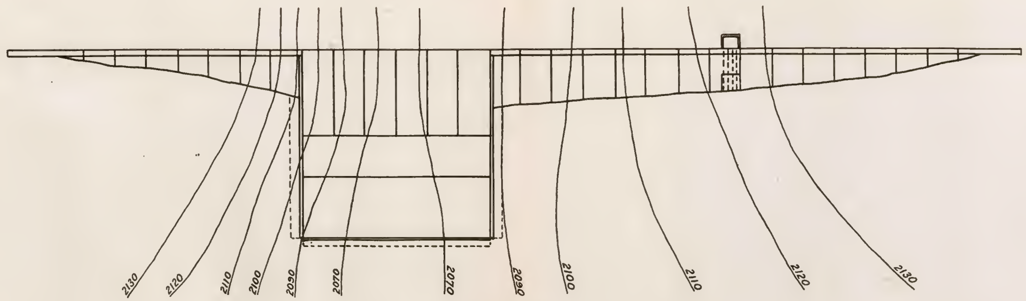


ELEVATION



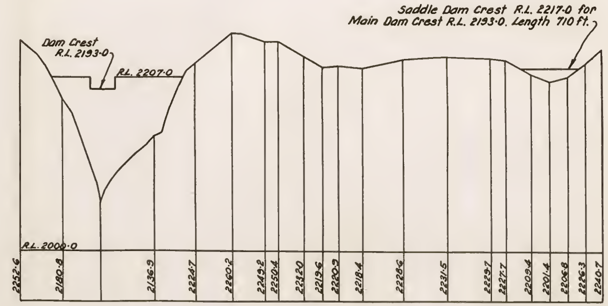
TYPICAL SECTION OF SADDLE DAM

Feet. 8 4 0 8 16 24 Feet.



PLAN

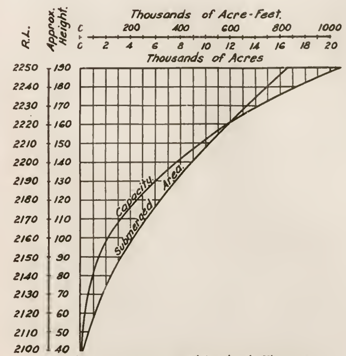
Feet 80 40 0 80 160 240 Feet.



SECTION THROUGH TRAVERSE

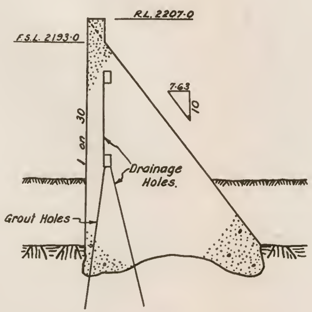
Horizontal. Feet. 600 300 0 600 1200 1800 Feet.

Vertical. Feet. 60 30 0 60 120 180 Feet.



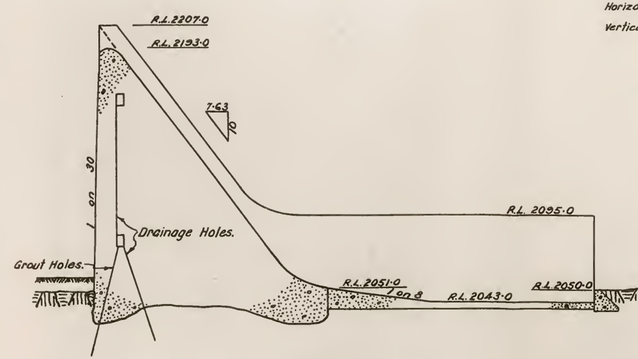
These curves are provisional only. They are based on survey information up to R.L. 2120·0 and on 50ft. Military contours at R.L.s 2150·0, 2200·0 & 2250·0.

CAPACITY AND SUBMERGED AREA CURVES



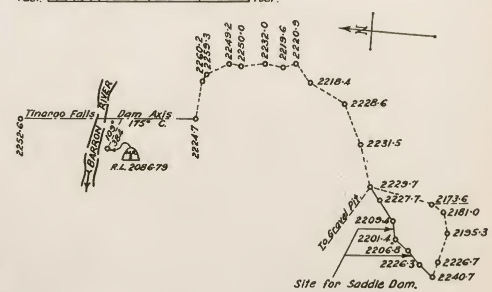
SECTION A-A

Feet. 30 0 30 60 90 Feet.



SECTION B-B

Feet. 30 0 30 60 90 Feet.



TRAVERSE ALONG SADDLE AND DAM SITE

Feet. 600 300 0 600 1200 1800 Feet.

QUEENSLAND

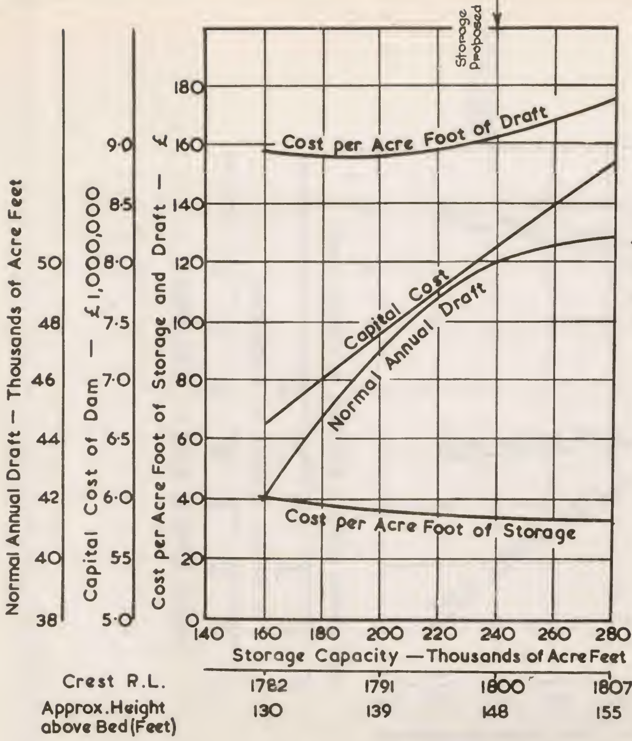
IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

TINAROO FALLS DAM - BARRON R. 63·00 M.

PROPOSED GRAVITY DAM - CREST R.L. 2193·0

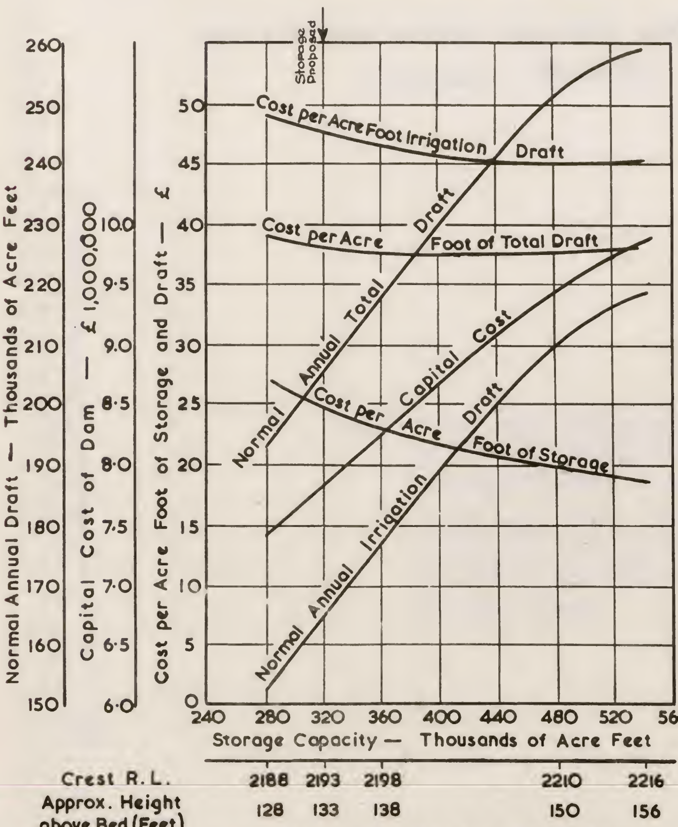
FIG. 19



Note: Normal Annual Draft is the draft available from the storage in 70% of years. In other years the draft is reduced as described in the report.

FIG. 20 a

NULLINGA STORAGE



Note: Total Draft includes 41,000 acre feet average annual contribution to Barron Falls Hydro-electric station

FIG. 20b

TINAROO FALLS STORAGE

QUEENSLAND IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA-DIMBULAH IRRIGATION PROJECT

ECONOMIC ANALYSES

STORAGES

FIG. 20

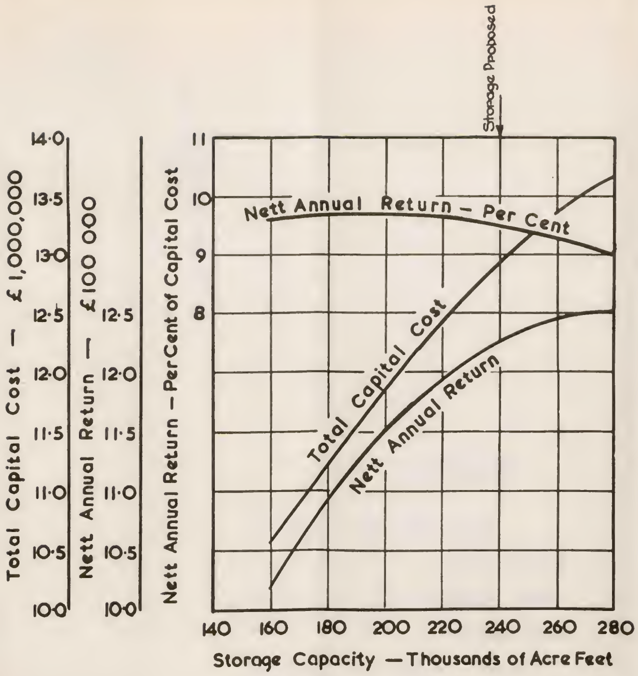


FIG. 21a

DEVELOPMENT FROM NULLINGA STORAGE

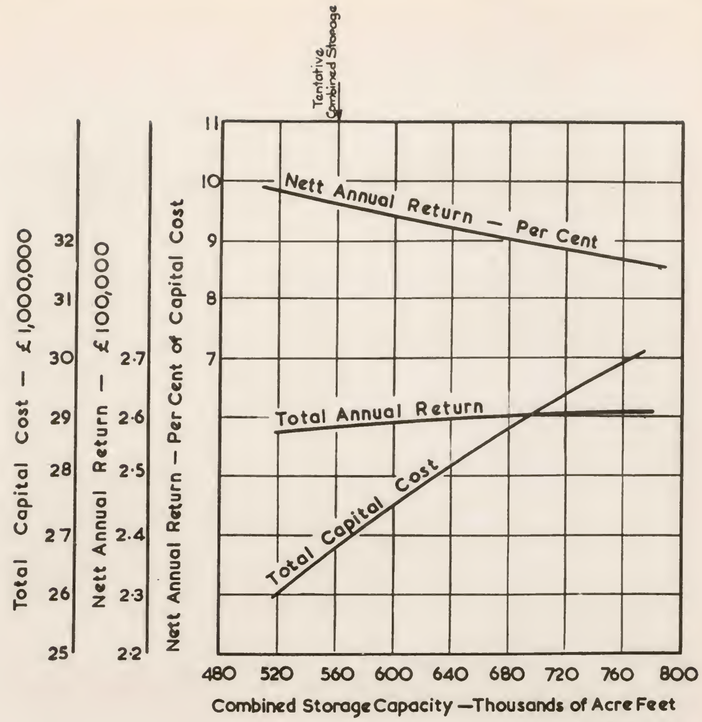


FIG. 21c

DEVELOPMENT FROM NULLINGA AND TINAROO STORAGES COMBINED

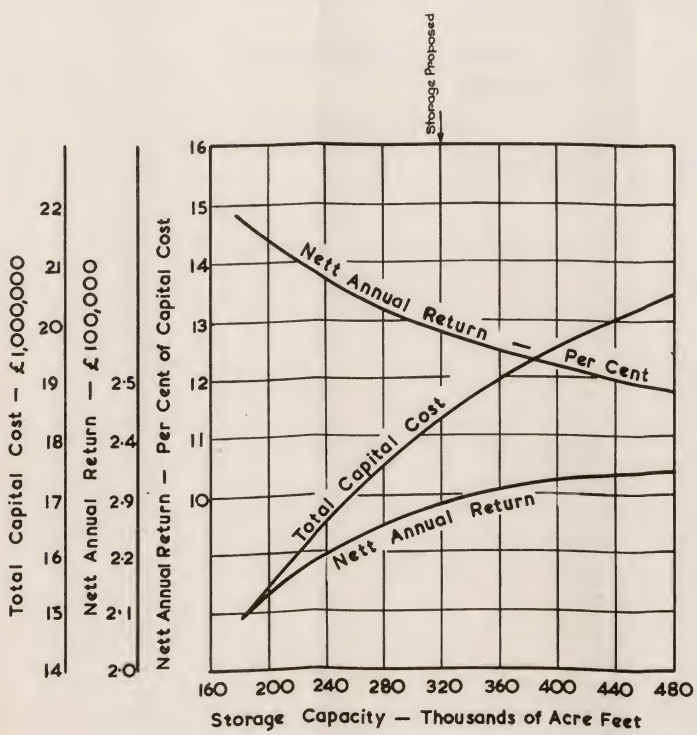


FIG. 21b

DEVELOPMENT FROM TINAROO STORAGE

Note : Total Cost includes the cost of storage, irrigation, drainage and other subsidiary works.

Nett Annual Return is taken as 40% of the increased value of production less water and drainage charges.

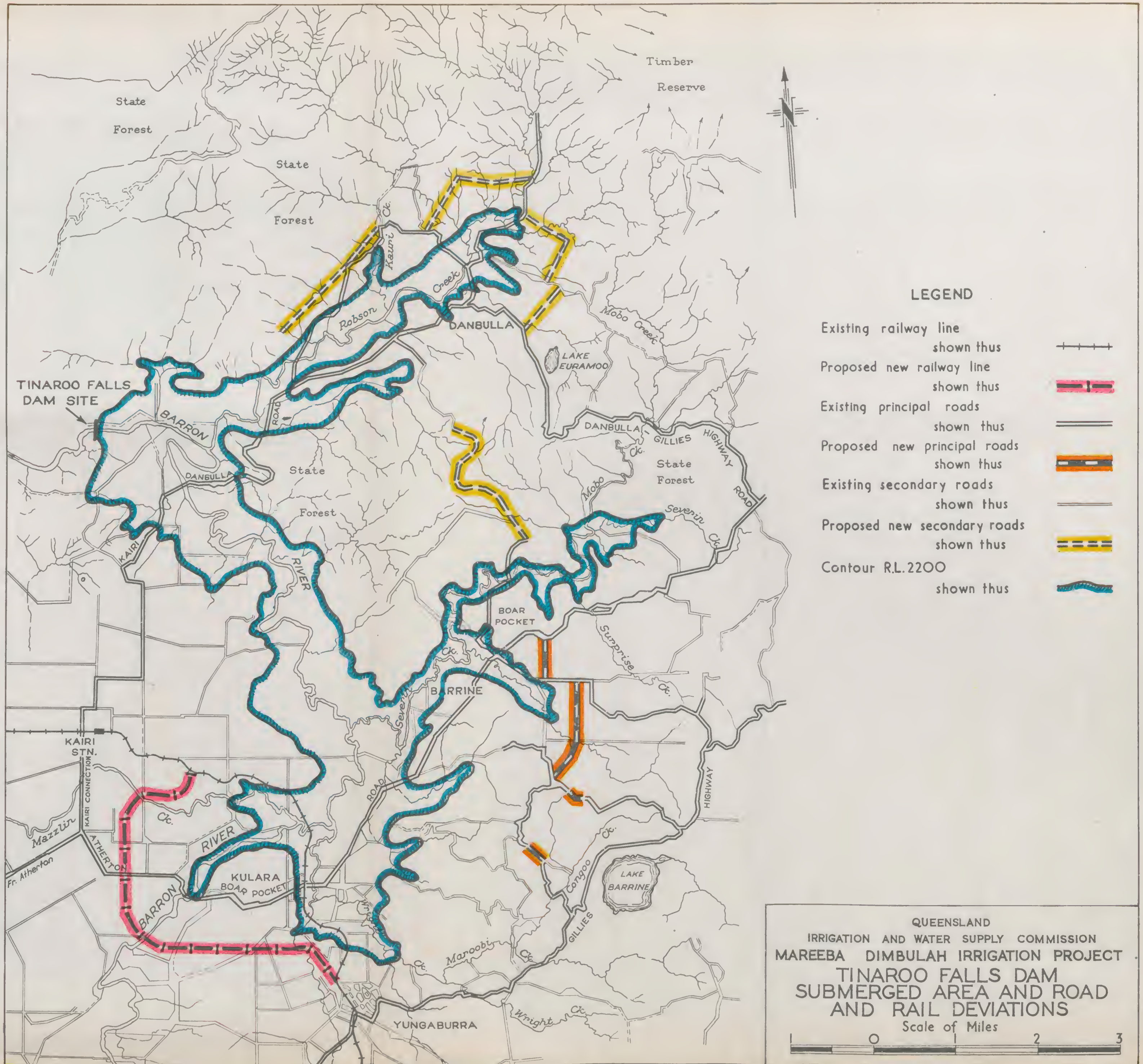
QUEENSLAND IRRIGATION AND WATER SUPPLY COMMISSION

MAREEBA–DIMBULAH IRRIGATION PROJECT

ECONOMIC ANALYSES

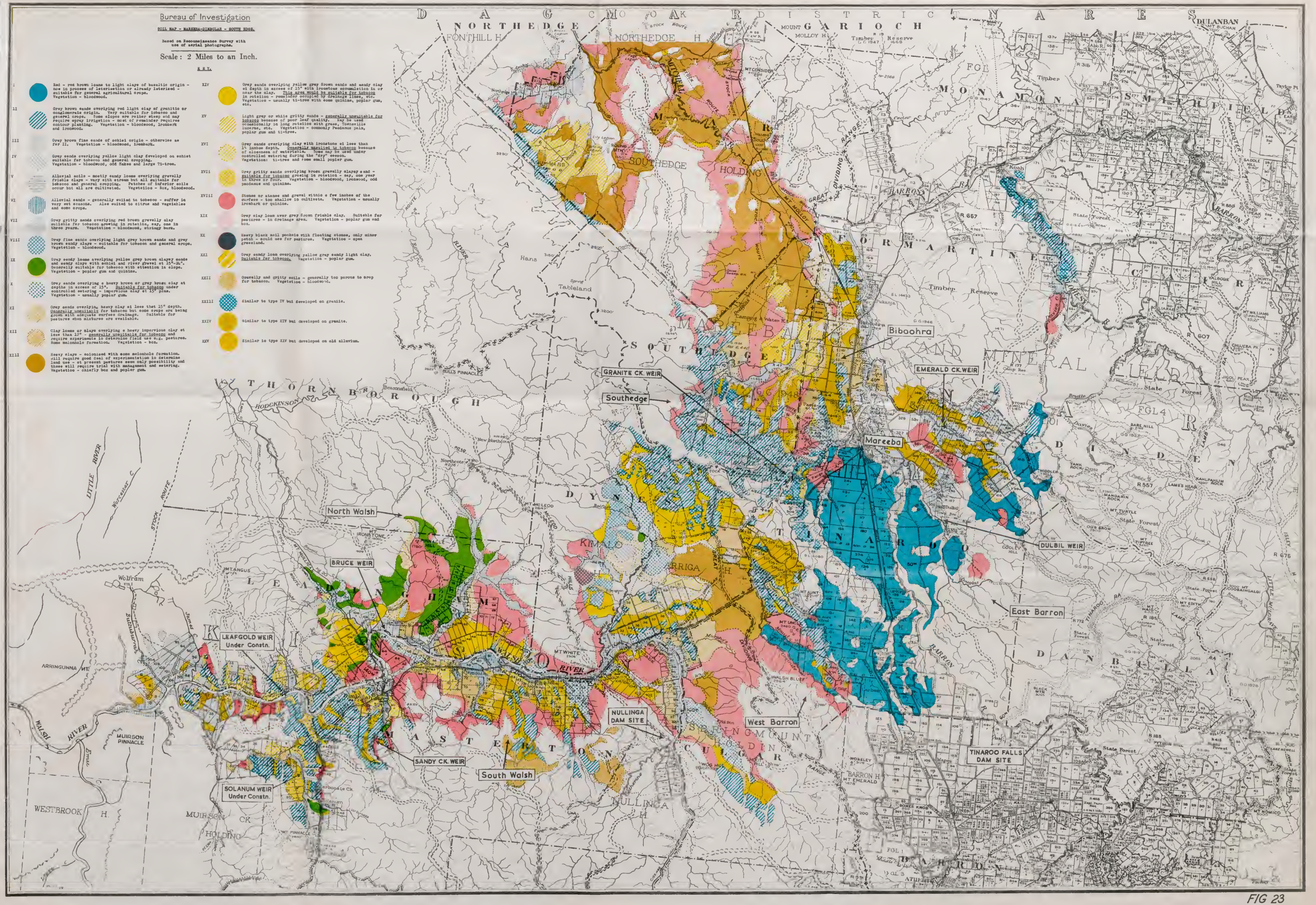
TOTAL CAPITAL COSTS AND ANNUAL RETURNS
STORAGE AND IRRIGATION WORKS

FIG. 21



Timber
Reserve
State
Forest
State
Forest
Robson Creek
Kairi Ck.
DANBULLA
Mobo Creek
LAKE EURAMOO
TINAROO FALLS DAM SITE
BARRON
ROAD
DANBULLA
State
Forest
DANBULLA - GILLIES HIGHWAY ROAD
Mobo Ck.
State
Forest
Severin Ck.
KAIRI
RIVER
BOAR POCKET
Surprise Ck.
BARRINE
Severin Ck.
KAIRI STN.
KAIRI CONNECTION
Mazlin Ck.
ATHERTON
Fr. Atherton
RIVER
KULARA
BOAR POCKET
BARRON
ROAD
HIGHWAY
Congoo Ck.
LAKE BARRINE
GILLIES
Maroobi Ck.
Wright Ck.
YUNGABURRA
LEGEND
Existing railway line shown thus
Proposed new railway line shown thus
Existing principal roads shown thus
Proposed new principal roads shown thus
Existing secondary roads shown thus
Proposed new secondary roads shown thus
Contour R.L. 2200 shown thus
QUEENSLAND
IRRIGATION AND WATER SUPPLY COMMISSION
MAREEBA DIMBULAH IRRIGATION PROJECT
TINAROO FALLS DAM
SUBMERGED AREA AND ROAD AND RAIL DEVIATIONS
Scale of Miles
1 0 1 2 3

FIG 22



Bureau of Investigation
SOIL MAP - MAREEBA-DIMBULAH - SOUTH EDGE.
Based on Reconnaissance Survey with use of aerial photographs.
Scale: 2 Miles to an Inch.
KEY.
I Red - red brown loams to light clays of basaltic origin - now in process of laterisation or already laterised - suitable for general agricultural crops. Vegetation - bloodwood.
II Grey brown sands overlying red light clay of granitic or conglomerate origin. Very suitable for tobacco and general crops. Some slopes are rather steep and may require spray irrigation - most of remainder requires contour planting. Vegetation - bloodwood, ironbark and ironwood.
III Grey brown fine sands of schist origin - otherwise as for II. Vegetation - bloodwood, ironbark.
IV Grey sands overlying yellow light clay developed on schist suitable for tobacco and general cropping. Vegetation - bloodwood, odd Hakea and large Ti-tree.
V Alluvial soils - mostly sandy loams overlying gravelly friable clays - vary with stream but all suitable for tobacco and general cropping. Patches of inferior soils occur but all are cultivated. Vegetation - Box, bloodwood.
VI Alluvial sands - generally suited to tobacco - suffer in very wet seasons. Also suited to citrus and vegetables and some crops.
VII Grey gritty sands overlying red brown gravelly clay suitable for tobacco growing in rotation, say, one in three years. Vegetation - bloodwood, stringy bark.
VIII Grey fine sands overlying light grey brown sands and grey brown sandy clays - suitable for tobacco and general crops. Vegetation - bloodwood.
IX Grey sandy loams overlying yellow grey brown clayey sands and sandy clays with schist and river gravel at 15"-24". Generally suitable for tobacco with attention to slope. Vegetation - poplar gum and quinine.
X Grey sands overlying a heavy brown or grey brown clay at depths in excess of 15". Suitable for tobacco under controlled watering - impervious clay at 15" plus. Vegetation - usually poplar gum.
XI Grey sands overlying heavy clay at less that 15" depth. Generally unsuitable for tobacco but some crops are being grown with adequate surface drainage. Suitable for pastures when mixtures are available.
XII Clay loams or clays overlying a heavy impervious clay at less than 12" - generally unsuitable for tobacco and require experiments to determine field use e.g. pastures. Some melonhole formation. Vegetation - box.
XIII Heavy clays - colonised with some melonhole formation. Will require good deal of experimentation to determine land use - at present pastures seem only possibility and these will require trial with management and watering. Vegetation - chiefly box and poplar gum.
XIV Grey sands overlying yellow grey brown sands and sandy clay at depth in excess of 15" with ironstone accumulation in or near the clay. This area would be suitable for tobacco in rotation - remainder occupied by drainage lines, etc. Vegetation - usually ti-tree with some quinine, poplar gum, etc.
XV Light grey or white gritty sands - generally unsuitable for tobacco because of poor leaf quality. May be used occasionally in long rotation with grass, Townsville lucerne, etc. Vegetation - commonly Pandanus palm, poplar gum and ti-tree.
XVI Grey sands overlying clay with ironstone at less than 15 inches depth. Generally unsuited to tobacco because of closeness of watertable. Some may be used under controlled watering during the "dry" season. Vegetation: ti-tree and some small poplar gum.
XVII Grey gritty sands overlying brown gravelly clayey sand - suitable for tobacco growing in rotation - say, one year in three or four. Vegetation - bloodwood, ironwood, odd pandanus and quinine.
XVIII Stones or stones and gravel within a few inches of the surface - too shallow to cultivate. Vegetation - usually ironbark or quinine.
XIX Grey clay loam over grey brown friable clay. Suitable for pastures - in drainage area. Vegetation - poplar gum and box.
XX Heavy black soil pockets with floating stones, only minor patch - could use for pastures. Vegetation - open grassland.
XXI Grey sandy loam overlying yellow grey sandy light clay. Suitable for tobacco. Vegetation - poplar gum.
XXII Gravelly and gritty soils - generally too porous to crop for tobacco. Vegetation - bloodwood.
XXIII Similar to type IV but developed on granite.
XXIV Similar to type XIV but developed on granite.
XXV Similar to type XIV but developed on old alluvium.
NORTHEDGE
GARIOCH
DULANBAN
MONAMON
SMITHFIELD
FORMARTINE
Biboohra
GRANITE CK. WEIR
Southedge
SOUTHEDGE
HOLDING
EMERALD CK. WEIR
Mareeba
THORNBOROUGH
HODGKINSON
North Walsh
BRUCE WEIR
LEAFGOLD WEIR
Under Constn.
ARRINGUNNA MT
WALSH RIVER
MUIRSON PINNACLE
SOLANUM WEIR
Under Constn.
WESTBROOK H.
SANDY CK. WEIR
South Walsh
NULLINGA DAM SITE
West Barron
TINAROO FALLS DAM SITE
East Barron
DULBIL WEIR
BARRON
NULLINGA H
Wolfram

FIG 23